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The Weather Bureau has not enough of the following numbers of the MONTHLY WEATHER REVIEW to meet even urgent requests for filling up files at institutions where the REVIEW is constantly being referred to. The return of any of these or of any 1919 or 1920 issues, especially November, 1919, will be greatly appreciated. An addressed franked slip may be had on application to the Chief, U. S. Weather Bureau, Washington, D. C.

1914: January, February, March, April, September, October, December.
1915: May, June, July, August.
1916: January, August.
1917: June.
1918: February, September.
1919: Any issue, especially November.
1920: Any issue, especially January.

SUPPLEMENT, No. 3.

MONTHLY WEATHER REVIEW

ALFRED J. HENRY, Editor.

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NOVEMBER, 1922.

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INFLUENCE OF THE WEATHER ON THE YIELD OF CROPS.

J. WARREN SMITH, Meteorologist.

[Weather Bureau, Washington, November 25, 1922.]

In the *Yearbook of the Department of Agriculture* for 1903, the writer presented certain charts or graphs showing the relation between the rainfall during the summer months, both separately and in combination, and the yield of corn in the important corn growing States.

In the MONTHLY WEATHER REVIEW for February, 1914, the effect of the weather on the yield of corn was presented, and in the same publication for May, 1915, the effect of the weather on the yield of potatoes was shown. In these last two papers, as well as in other similar studies made from time to time, the close relation between the weather of certain periods and the yield of crops was expressed by the correlation coefficient.

Both methods are useful. The first, to present the relation between two factors graphically; the second, to show the kind of weather that has the greatest influence in varying the yield of a crop, as well as the most critical period of growth, especially when preceded by the dot charts and supported by the partial correlation.

A thorough study of the subject has indicated to many the possibility of predicting the yield of crops from a knowledge of antecedent weather conditions. This may be done, of course, through regression equations, although the interrelation of the various weather factors and the differences in their effects through different periods of growth are extremely complicated and possibly await entirely satisfactory resolution.

The writer and his associates have attacked the question from many different angles. Long ago we were convinced that the calendar month covers too long a period of time and is too arbitrary in its limits to be used successfully. It has been used, however, because climatological data are tabulated and published in monthly units. To tabulate these data in units of shorter periods entails an enormous amount of work, as every one knows who has made the attempt.

In our study of weather and corn we tabulated rainfall and temperature data by ten-day periods, for central Ohio, with fairly satisfactory results.

Within the past two years the Division of Agricultural Meteorology of the Weather Bureau has obtained the daily average rainfall, temperature, and sunshine values for parts of States, or whole States, in important crop districts, and has summarized these daily values into *weekly* averages and totals. The highly satisfactory results given below are based on these weekly values, and show pretty conclusively that the week is probably the most convenient unit of time to use, even if the clerical work is so large.

Further, these studies have emphasized the fact that the important stages of development reached by a crop which varies in different years, must be found, but there is a marked dearth of information of this character, caused partly by lack of intensive study, but also because of the indefinite results that come from attempted correlations between general crop production on the agricultural scale and the reported weather conditions derived from the general meteorological observations. This should be remedied by the inauguration of closely related observations of weather conditions with conditions of growth and yield, including phenological observations in connection with important crops at all the agricultural experiment stations, and possibly elsewhere.

The results recently secured from studies of existing data giving weather conditions and crop yields have, however, proven so encouraging as to justify a very brief publication with the object of reporting upon the progress being made in formulating the influence of the weather on crop production and reserving, for a future report, the presentation of the full details when the effects of the several factors have been more accurately evaluated, the methods better developed, and the results checked and verified more rigorously than is now possible.

It seems proper at this point to say that studies of this kind are continually vitiated and made difficult by material errors of considerable magnitude in the statistics giving *yield per acre*. Obviously, the whole error in this datum necessarily expresses itself in the form of final error of calculated yield, and also tends to make confusion in, and irrational outcome of, the weather relations tentatively adopted. Such encouraging results were secured by the present method in an initial study of the influence of the weather on oats that the work was extended to the corn crop in north central Illinois, and finally to the cotton crop in South Carolina.

THE RELATION OF WEATHER TO THE YIELD OF OATS.

One of the first districts covered by the daily tabulation of meteorological data was in north-central Illinois, and included the counties of De Witt, Logan, McLean, Macon, Marshall, Mason, Menard, Peoria, Stark, Tazewell, and Woodford, 11 in all. The period covered was from March 1 to August 31, inclusive, for the 27 years from 1894 to 1920, inclusive.

The temperature data were from three well-distributed stations in this area, while the rainfall averages were obtained from all the rainfall stations in the district, eight in number. Weekly total precipitation values were determined from these daily averages, and weekly average maximum, minimum, and mean temperatures calculated for each year.

The average yield of oats for the 11 counties for each year was obtained from the figures published by the United States Department of Agriculture. These yields vary from 48 bushels to the acre in 1917, to 16.2 bushels in 1895. The yield for the 27 years averaged 34.8 bushels.

Charts were made showing graphically the variations of temperature and precipitation from the normal for

each week of each year. These were grouped by yield values in order to determine by inspection, if possible, how the weather during the years of large yields differed from those with small yields.

Weekly weather and crop bulletins were studied to determine favorable and unfavorable conditions for oats, as well as to obtain dates of seeding, germination, heading, ripening, and harvesting for each year as far as possible. These data were obtained from other sources also.

WEATHER INDEX VALUES.

Many charts, diagrams, and mathematical calculations were made to determine critical periods, workable equations, and the like. These, as well as previous studies, showed that the oat plant does best in comparatively cool, moist climates; that in northern Ohio, Indiana, and Illinois, and in Iowa, April should be moderately dry to insure a good seed bed, and comparatively warm for quick germination; also that June should be cooler and slightly wetter than normal to allow for proper heading and ripening, as hot and dry weather while the heads are filling is decidely unfavorable. It was found, further, that a cold winter has a favorable influence on the yield.

A long effort to establish workable, empirical relations between both favorable and unfavorable weather conditions led to a decision to consider only *unfavorable* weather; in other words, to consider all weather favorable that was not plainly unfavorable. This idea had been given only slight consideration heretofore, but it has been a very useful factor in the present effort to estimate the yield of crops from the weather conditions.

In applying this method a careful study is made of the weather conditions over the region covered, week by week, from the 1st of March to the 31st of August, and year by year. An estimate is made of the unfavorable effect of features of the weather which are considered detrimental, and a sum is obtained of these harmful effects, which becomes the *weather index* for the year. The results in the present case are shown in Table 1, where column 2 gives the weather index and column 3 the yield of oats for each year.

TABLE 1.—*Influence of the weather on the yield of oats in north-central Illinois for the period 1894 to 1920, inclusive.*

[In bushels per acre.]

1	2	3	4	5	6	7
Year.	Weather index w.	Yield Y.	w^2.	$w \times Y$.	Calculated yield y.	Variation from actual v.
1894	17	40.5	289	688.5	39.5	−1.0
1895	40	16.2	1,600	648.0	16.8	+0.6
1896	28	29.9	784	837.2	28.6	−1.3
1897	21	36.9	441	774.9	35.6	−1.3
1898	32	24.7	1,024	790.4	24.7	0
1899	12	44.5	144	534.0	44.4	−0.1
1900	13	43.6	169	566.8	43.5	−0.1
1901	25	33.1	625	827.5	31.6	−1.5
1902	15	41.8	225	627.0	41.5	−0.3
1903	28	29.1	784	814.8	28.6	−0.5
1904	26	32.3	676	839.8	30.6	−1.7
1905	16	41.3	256	660.8	40.5	−0.8
1906	27	30.5	729	823.5	29.6	−0.9
1907	29	28.5	841	826.5	27.7	−0.8
1908	36	20.7	1,296	745.2	20.7	0
1909	22	36.1	484	794.2	34.6	−1.5
1910	23	35.8	529	823.4	33.6	−2.2
1911	28	30.4	784	851.2	28.6	−1.8
1912	11	45.8	121	503.8	45.4	−0.4
1913	32	24.4	1,024	780.8	24.7	+0.3
1914	24	34.9	576	837.6	32.6	−2.3
1915	11	45.5	121	500.5	45.4	−0.1
1916	20	37.7	400	754.0	36.5	−1.2
1917	8	48.0	64	384.0	48.4	+0.4
1918	16	41.3	256	660.8	40.5	−0.8
1919	29	27.7	841	803.3	27.7	0
1920	19	38.7	361	735.3	37.5	−1.2
Sums	608	939.9	15,444	19,433.8		
Average	22.5	34.8				0.82

From the weather index and yield values, a regression equation, $y = a + bw$, was calculated by the method of least squares, as shown by the table, and a was found to be 56.3 and b −0.988; w is the index number, and y the yield as calculated by the equation; v shows the variations of the calculated yield from the actual.

The average variation of the calculated yield from the actual for the 27 years, as shown by column 7, is only 0.8 bushels per acre, while the greatest variation was −2.3 bushels in 1914. These values are only 2 and 6 per cent, respectively, of the average yield. The correlation coefficient for the weather index and the yield figures is 0.994 ±0.012.

The regression equation indicates that the maximum yield of oats, averaged for the whole area under discussion, need not be expected to reach above 56.3 bushels per acre.

Testing the value of the equation.—To test the value of a study of this character, the equation must be applied to a period not included in evolving the equation. This was done for 1921, with the result that the calculated yield was 24.7 bushels per acre, while the actual yield was 24.9 bushels, a variation of only 0.2 bushels.

To further test the accuracy of the figures and also to determine whether they are applicable in other districts, they were applied to the whole State of Illinois, as well as to the States of Ohio and Iowa, for the four years 1918 to 1921, inclusive, giving the following results:

TABLE 2.—*Weather and the yield of oats, 1918 to 1921.*

[Bushels per acre.]

ILLINOIS.

Year.	Yield.	Calculated yield.	Variation.	Per cent.
1918	44.0	45.4	+1.4	3
1919	30.0	32.8	+2.8	9
1920	40.0	37.5	−2.5	6
1921	26.0	24.7	−1.3	5

OHIO.

1918	44.0	43.7	−0.3	0.7
1919	33.5	33.0	−0.5	1
1920	44.2	43.2	−1.0	2
1921	23.0	26.6	+3.6	16

IOWA.

1918	39.4	38.5	−0.9	2
1919	34.7	36.5	+1.8	5
1920	39.1	38.3	−0.8	2
1921	26.0	24.2	−1.8	7

In making up the weather index for Iowa, only half as much weight was given to winter temperatures as in the other States, but otherwise the same values were used, showing that the laws are applicable in most of the main oat-growing section, in this latitude at least.

The weather data for these States were obtained from weekly charts in the National Weather and Crop Bulletins, hence are not so complete or definite as if the exact daily or weekly averages for the State were calculated. It is not surprising, therefore, that some of the variations in Table 2 are greater than in the small district in Illinois where daily averages were obtained. Figure 1 shows the variation of the calculated from the recorded yield of oats in north-central Illinois for each year from 1894 to 1921. The yield for 1921 was calculated in advance. Figure 2 shows the relation between the actual and calculated yields of oats for 1918 to 1921 in Illinois, Ohio, and Iowa, respectively.

THE RELATION OF THE WEATHER TO THE YIELD OF CORN.

Corn is a sun-loving crop of tropical origin; but it is so flexible in its requirements and so readily adapts itself to its surroundings that it is successfully grown over wide climatic ranges.

Previous studies by the writer and others show that in the northern Ohio and central Mississippi Valleys the most important weather factor in varying the yield of corn from year to year is the amount of rainfall during that stage of growth represented by the month of July. At the same time it is plain that the yield in any district

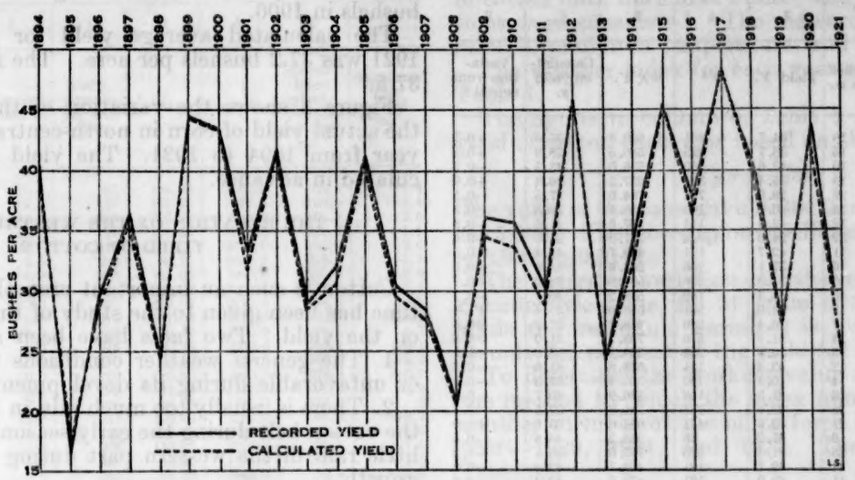


FIG. 1.—The relation of the actual to the calculated yield of oats in north-central Illinois. The year 1921 was calculated in advance.

The region of most intensive cultivation in the United States is where the summer temperature averages from 70° to 80° and where the annual precipitation is between 25 and 50 inches and the rainfall for July and August is about 7 or 8 inches.

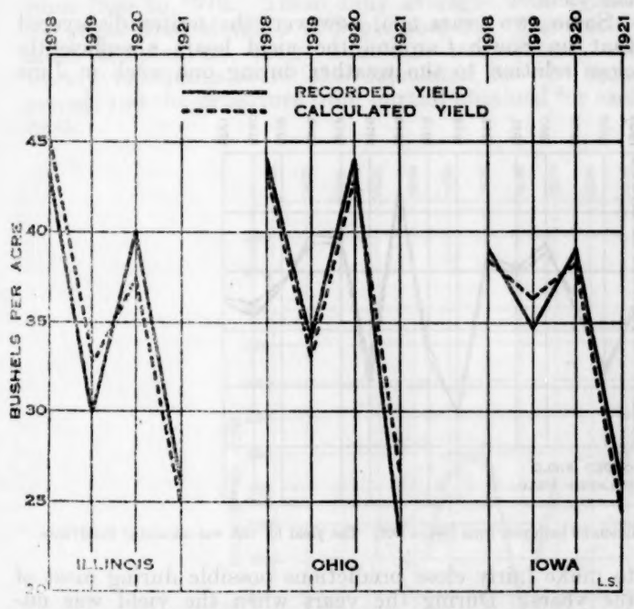


FIG. 2.—The three diagrams show the relation between the actual and calculated yield of oats for 1918 to 1921 in Illinois, Ohio, and Iowa, respectively. The calculated yield values were based on the equation evolved from the north-central Illinois data, 1894 to 1920.

can not be predicted from a knowledge of the rainfall during July alone, but that other factors must be considered.

Mr. J. B. Kincer has obtained a very high correlation between the weather and corn yield by considering the temperature during June and the rainfall in July, but even then other factors must be taken into account if an attempt is made to predict the yield.

The writer, therefore, after completion of the successful effort to predict the yield of oats by the use of a weather index, as indicated above, decided to make an exhaustive study of weather and corn yield for the same area in north-central Illinois as was used in the study of oats. The yield figures were obtained from the Department of Agriculture, and the same weekly meteorological data used that were tabulated for the oats study.

Large charts were prepared for each year and an effort made to evolve a weather index that could be used in correlating the yield with the previous weather. As in the case of oats, all available facts were obtained to show the development of the corn crop each year and the weather effects during these different periods.

Profiting by the experience in the study of weather and oats, a weather index based on unfavorable conditions alone was obtained for each year that could be used in evolving a regression equation.

Believing that the most critical periods in the growth of corn in the latitude or area covered are earlier than August, and wishing to ascertain whether it might be possible to predict the yield of corn by the close of July, the weather data up to the first of August only were considered.

Table 3 gives the weather index (w) in column 2, while column 6 shows the calculated yield (y), and

column 7 the variation of the calculated yield from the actual (Y).

TABLE 3.—*Influence of the weather on the yield of corn in north-central Illinois for the period 1894 to 1920, inclusive.*

[In bushels per acre.]

1	2	3	4	5	6	7
Year.	Weather index w.	Yield Y.	w^2	$w \times Y$.	Calculated yield y.	Variation from actual v.
1894	19	34.7	361	659.3	35.4	+0.7
1895	15	38.7	225	580.5	38.9	+0.2
1896	10	43.6	100	536.0	43.3	−0.3
1897	18	35.4	324	637.2	36.3	+0.9
1898	28	28.0	784	784.0	27.5	−0.5
1899	14	40.6	196	568.4	39.8	−0.8
1900	12	42.3	144	507.6	41.6	−0.8
1901	32	24.6	1,024	787.2	24.0	−0.6
1902	11	42.7	121	469.7	42.4	−0.3
1903	16	37.1	256	593.6	38.0	+0.9
1904	16	37.3	256	596.8	38.0	+0.7
1905	13	41.4	169	538.2	40.7	−0.7
1906	19	34.0	361	646.0	35.4	+1.4
1907	17	36.4	289	618.8	37.2	+0.8
1908	24	31.8	576	763.2	31.0	−0.8
1909	16	36.9	256	590.4	38.0	+1.1
1910	12	42.4	144	508.8	41.6	−0.8
1911	14	40.1	196	561.4	39.8	−0.3
1912	13	41.3	169	536.9	40.7	−0.6
1913	28	27.9	784	781.2	27.5	−0.4
1914	21	32.6	441	684.6	33.6	+1.0
1915	6	47.2	36	283.2	46.8	−0.4
1916	25	31.4	625	785.0	30.1	−1.3
1917	11	42.7	121	469.7	42.4	−0.3
1918	11	43.0	121	473.0	42.4	−0.6
1919	15	38.6	225	579.0	38.9	+0.3
1920	17	36.1	289	613.7	37.2	+1.1
Sums	453	1,008.8	8,593	16,053.4	1,008.5	
Means	16.78	37.36			37.35	0.69

The equation used in calculating the values, y, in column 6, is—

$$y = a + bw$$

in which w is the weather index. The most probable values of the constants a and b are given by the solution of two normal equations. (See any good text on Methods of Least Squares.) Making the calculation these constants become a, 52.1, and b, —0.8784.

Introducing the values found in the present case the equation becomes—

$$y = 52.1 - 0.8784\ w$$

This equation gives the calculated yield, y, to be expected from the final value, w, found from the summation of adverse weather conditions.

The correlation coefficient for w and Y is—

—0.9797; probable error, ±0.012.

The figures in column 7, Table 3, show that the average variation of the calculated from the recorded yield was 0.7 bushels per acre, and the greatest variation +1.4 bushels in 1906.

The calculated average yield for these counties in 1921 was 37.2 bushels per acre. The recorded yield was 37.5

Figure 3 shows the variation of the calculated from the actual yield of corn in north-central Illinois, for each year from 1894 to 1921. The yield for 1921 was calculated in advance.

THE RELATION OF THE WEATHER TO THE YIELD OF COTTON.

Cotton is such an important crop that a good deal of time has been given to the study of the effect of weather on the yield. Two facts have been ascertained:

1. The general weather conditions that are favorable or unfavorable during its development, and

2. There is usually too much rain in the eastern part of the cotton belt during the early season of growth and too little rain in the western part during the late season of growth.

Although moderately high correlations can be found between the weather and yield, the opinion has been freely expressed that the cotton plant is so weed-like in its growth and continues to bloom and fruit until the end of the growing season that, unlike corn and other grains, it will never be possible to identify any particular short period when the weather has a dominating influence on the yield.

Some two years ago, however, the writer discovered that, in South Carolina the yield bears a sufficiently close relation to the weather during one week in June to make fairly close predictions possible during most of the years. During the years when the yield was unusually high, and most of the time when the yields were very low, the variation between the predicted and actual yield was considerable, showing that other factors must be taken account of.

With these facts in mind, as well as of the success attained in calculating a weather index that could be closely correlated with oat and corn yields, an attempt was made to handle weather and cotton in the same

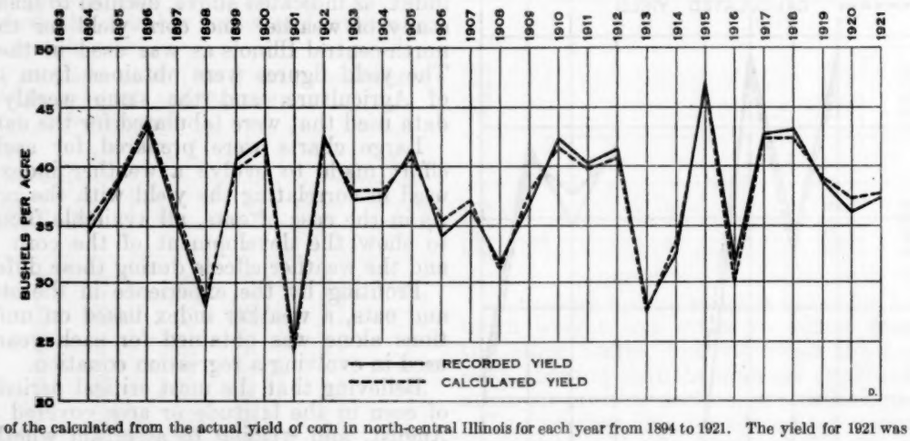


FIG. 3.—The variation of the calculated from the actual yield of corn in north-central Illinois for each year from 1894 to 1921. The yield for 1921 was calculated in advance.

manner. Further, because there is such a close relation between the weather for one week in June and the yield it was decided to use the weather conditions preceding the first of July in evolving the weather index.

TABLE 4.—*Influence of the weather on the yield of cotton in South Carolina for the period 1899 to 1919, inclusive.*

1	2	3	4	5	6	7
Year.	Weather-Index w.	Yield, pounds per acre Y.	w^2	$w \times Y$	Calculated yield, pounds per acre, y.	Variation from actual yield, v.
1899	12.5	165	156.25	2062.5	169.4	+4.4
1900	12.5	167	156.25	2087.5	169.4	+2.4
1901	14.5	141	210.25	2044.5	138.2	−2.8
1902	10.5	199	110.25	2089.5	200.5	+1.5
1903	11.5	178	132.25	2047.0	185.0	+7.0
1904	9.5	215	90.25	2042.5	216.1	+1.1
1905	9.0	220	81.00	1980.0	223.9	+3.9
1906	12.0	175	144.00	2100.0	177.2	+2.2
1907	10.0	215	100.00	2150.0	208.3	−6.7
1908	9.0	219	81.00	1971.0	223.9	+4.9
1909	10.0	210	100.00	2100.0	208.3	−1.7
1910	9.5	216	90.25	2052.0	216.1	+0.1
1911	5.0	280	25.00	1400.0	286.2	+6.2
1912	10.0	209	100.00	2090.0	208.3	−0.7
1913	8.5	235	72.25	1997.5	231.7	−3.3
1914	7.0	255	49.00	1785.0	255.0	0
1915	10.0	215	100.00	2150.0	208.3	−6.7
1916	13.0	160	169.00	2080.0	161.6	+1.6
1917	10.5	208	110.25	2184.0	200.5	−7.5
1918	7.5	250	56.25	1875.0	247.2	−2.8
1919	8.0	243	64.00	1944.0	239.4	−3.6
Sum	210.0	4375	2197.5	42232.0	.....	.....
Mean	10	208.33	.....	.....	.....	3.4

The State used in this study was South Carolina. The cotton-yield figures are from the publications of the Department. The average rainfall for all the meteorological stations in the State was calculated for each day from 1899 to 1919. These daily averages were totaled by weeks from March 5 to September 24. The weekly mean temperature, mean minimum temperature, and weekly cloudiness were also calculated for the same period, and the departure from normal obtained for each week.

Charts were prepared and information obtained regarding crop development and weather effects, as was done in studying oats and corn.

After all this and much more preliminary work had been done, a weather index was calculated for each year from 1899 to 1919, inclusive, based on the unfavorable effects of the weather during the period from planting of cotton until the end of June. Only unfavorable conditions were considered. The meteorological factors were rainfall, minimum temperature, and cloudiness.

The weather index for each year is given in column 2, Table 4.

The figures in column 6, Table 4, show the calculated yield of cotton each year based on the equation

$$y = a + bw.$$

The value of the constant a is 364.0, and of the constant b −15.569. The correlation coefficient for w and Y is $-0.927, \pm 0.0147$.

The average variation of the calculated from the recorded yield for the 21 years is 3.4 pounds an acre, while the maximum variation is −7.5 pounds in 1917, or only 3.6 per cent of the yield for that year.

To determine the working value of the equation and the method by which the index numbers are calculated, another member of the office force applied them to the years 1920, 1921, and 1922. The results appear in Table 5.

TABLE 5.—*Test of equation by estimating the yield of cotton in advance in South Carolina.*

1	2	3	4	5	6
Year.	Yield.	Predicted.	Variation.	[1] After allowing for boll-weevil damage.	
				Predicted.	Variation.
1920	254	278.4	+24.4	250.6	−3.4
1921	140	177.2	+37.2	141.8	+1.8
1922	[2] 139	177.2	+38.2	141.8	+2.8

[1] Boll-weevil damage calculated as 10 per cent in 1920 and 20 per cent in 1921 and 1922.
[2] Estimated by Department of Agriculture on Sept. 25, 1922.

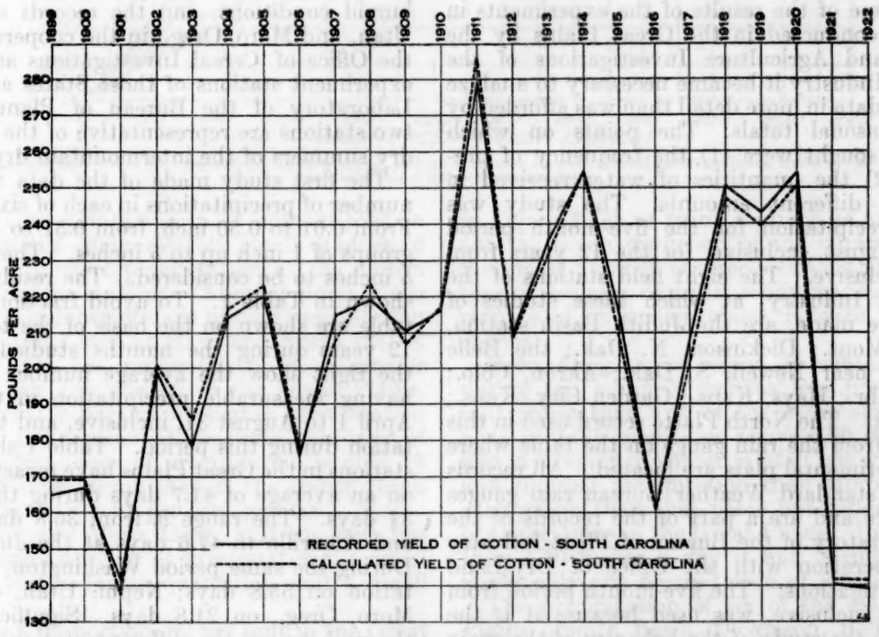


FIG. 4.—The variation of the calculated from the recorded yield of cotton in pounds of lint per acre in South Carolina for each year from 1899 to 1922, inclusive. The yields for 1920, 1921, and 1922 were calculated in advance.

ALLOWANCE FOR BOLL-WEEVIL DAMAGE.

Since South Carolina was entirely free from boll-weevil damage for most of the period covered by the data used in computing the constants of the regression equation, whereas such damage was considerable over the period of the test years, the comparatively large error between the actual and the estimated yield not only necessitates a correction for boll-weevil effects, but shows the soundness of the method, because a correction is required for the introduction of adverse crop effects not included in the investigation. In the absence of other exact data an allowance of 10 per cent for 1920 and 20 per cent for 1921 and 1922 brings the actual and calculated effects into close accord. We are satisfied that these allowances are fair ones and that the working reliability of the method and equation has been demonstrated.

The next step should be to apply these methods and equations to other oat, corn, and cotton States, and this will be done as soon as the data can be tabulated.

We are sure that the methods can be refined with more work, and also that they will need to be modified somewhat when working in districts with different climatic conditions. It seems to the writer, however, that the principle has been demonstrated and that after other important crop districts have been covered it will be possible to predict the yield of the important crops considerably before the harvesting time.

It will be seen in the studies noted above that although the weather must be taken into account up to about the harvest date for oats, the probable yield of corn can be determined by the end of July and of cotton at the end of June in the eastern part of the belt.

Undoubtedly the weather in July, and possibly August, must be considered in connection with cotton in the western part of the belt and that August may need to be taken into account in connection with corn in the central and western Great Plain States.

Figure 4 gives the variation of the calculated from the recorded yield of cotton in pounds of lint per acre in South Carolina for each year from 1899 to 1922, inclusive. The yields for 1920, 1921, and 1922 were calculated in advance.

THE DAILY QUANTITIES IN WHICH SUMMER PRECIPITATION IS RECEIVED.

By JOHN S. COLE, Agriculturist.

[U. S. Bureau of Plant Industry, Washington, D. C., November 15, 1922.]

SYNOPSIS.

The daily precipitation during the five months from April to August, inclusive, for the 12-year period from 1908 to 1919, inclusive, was studied at eight stations in the Great Plains and at Washington, D. C., Nephi, Utah, and Moro, Oreg. During 153 days of these months Washington had measurable precipitation on 55.8 days, the Great Plains on 41.7 days, Nephi on 26.3 days, and Moro on 21.8 days. Within limits, the quantity of precipitation is not determined by the number of days on which it occurs. In the Great Plains 82 per cent of the days having measurable precipitation have 0.50 inch or less and 45 per cent have 0.10 inch or less. In quantities from 0.05 inch up to a critical point, which is approximately 0.30 inch at Moro and Nephi, from 0.70 inch to 1.10 inches in the Great Plains, and 1.20 inches at Washington, the frequency of a given precipitation is inversely proportional to its amount. Above the critical point the decrease in frequency is more rapid than increase in amount. The number of precipitations below 0.05 inch increases with decreasing quantity but not in the same proportion.

In studying some of the results of the experiments in crop production conducted in the Great Plains by the Office of Dry-Land Agriculture Investigations of the Bureau of Plant Industry it became necessary to analyze the precipitation data in more detail than was afforded by monthly and seasonal totals. The points on which information was sought were (1) the frequency of precipitation and (2) the quantities of water received in precipitations of different amounts. The study was made on the precipitation for the five-month period from April to August, inclusive, for the 12 years from 1908 to 1919, inclusive. The eight field stations of the Bureau of Plant Industry, at which these studies of precipitation were made, are the Judith Basin station, near Moccasin, Mont.; Dickinson, N. Dak.; the Belle Fourche station, near Newell, S. Dak.; Akron, Colo.; North Platte, Nebr.; Hays, Kans.; Garden City, Kans.; and Amarillo, Tex. The North Platte record used in this study is the one from the rain gauge on the table where the dry-land experimental plats are located. All records were made from standard Weather Bureau rain gauges with free exposure and are a part of the records of the Biophysical Laboratory of the Bureau of Plant Industry obtained in cooperation with the Office of Dry-Land Agriculture Investigations. The five-month period from April to August, inclusive, was used because it is the period with which the study of the behavior of the grain crops is chiefly concerned. The study was made for 12 years because the eight stations selected for it had continuous records for that period; it seemed sufficiently long to give reliable averages and fairly smooth curves, and it was the period covered by the study of crops and soil moisture.

The precipitation is recorded in quantities received daily and consequently does not permit more refined study than of the number of days having precipitation of given quantities. In this paper a precipitation is therefore understood to be a day having precipitation of measurable quantity.

To afford comparison with other conditions the study was extended to include the Weather Bureau records of precipitation at Washington, D. C., as representative of humid conditions, and the records obtained at Nephi, Utah, and Moro, Oreg., in the cooperative work between the Office of Cereal Investigations and the agricultural experiment stations of those States and the Biophysical Laboratory of the Bureau of Plant Industry. These two stations are representative of the winter rainfall and dry summers of the intermountain dry-farming region.

The first study made of the data was a count of the number of precipitations in each of six groups, as follows: From 0.01 to 0.50 inch, from 0.51 to 1 inch, and then in groups of 1 inch up to 5 inches. There were none above 5 inches to be considered. The results of this study are shown in Table 1. To avoid fractions, the data in this table are shown on the basis of the total number in the 12 years during the months studied. The columns at the right show the average number of days each year having measurable precipitation in the 153 days from April 1 to August 31, inclusive, and the average precipitation during this period. Table 1 shows that the eight stations in the Great Plains have measurable precipitation on an average of 41.7 days during this period, or every $3\frac{2}{3}$ days. The range is from 36.8 days at Garden City and Amarillo to 47.6 days at the Judith Basin station. During the same period Washington, D. C., had precipitation on 55.8 days; Nephi, Utah, on 26.3 days; and Moro, Oreg., on 21.8 days. Significant differences are shown between the different stations or sections of the

Great Plains as well as between the Great Plains as a whole and the other regions having different quantities or types of rainfall. It is evident from it that within limits, as between different stations in the Great Plains, the quantity of precipitation is not determined by the number of days on which it occurs. The Dickinson and Belle Fourche stations have almost exactly the same number of days of precipitation, but the quantity at Dickinson is 2.27 inches, or 24 per cent, greater than at the Belle Fourche station. The latter place has the greater number of precipitations less than 0.50 inch and the former of precipitations between 1 and 2 inches. Exactly the same number of precipitations at the Belle Fourche and the Hays stations yield 9.27 inches at the former and 14.78 inches at the latter.

from 0.01 inch to 0.50 inch and 12 per cent within the next half-inch group it appeared desirable to study the distribution in more detail. The number of precipitations of each unit measurement (0.01 inch) was therefore determined. The number of precipitations multiplied by the quantity gave the amount contributed by that quantity to the total. Study of the material showed that satisfactory results could be obtained by combining the quantities into groups of 0.10 inch. The totals were divided by 12 to obtain the average annual contribution of each 0.10-inch group to the total precipitation for the five months. The data so obtained are shown in Table 2 for eight stations in the Great Plains and Washington, D. C., Nephi, Utah, and Moro, Oreg. The curves formed by successive additions of these quantities are plotted

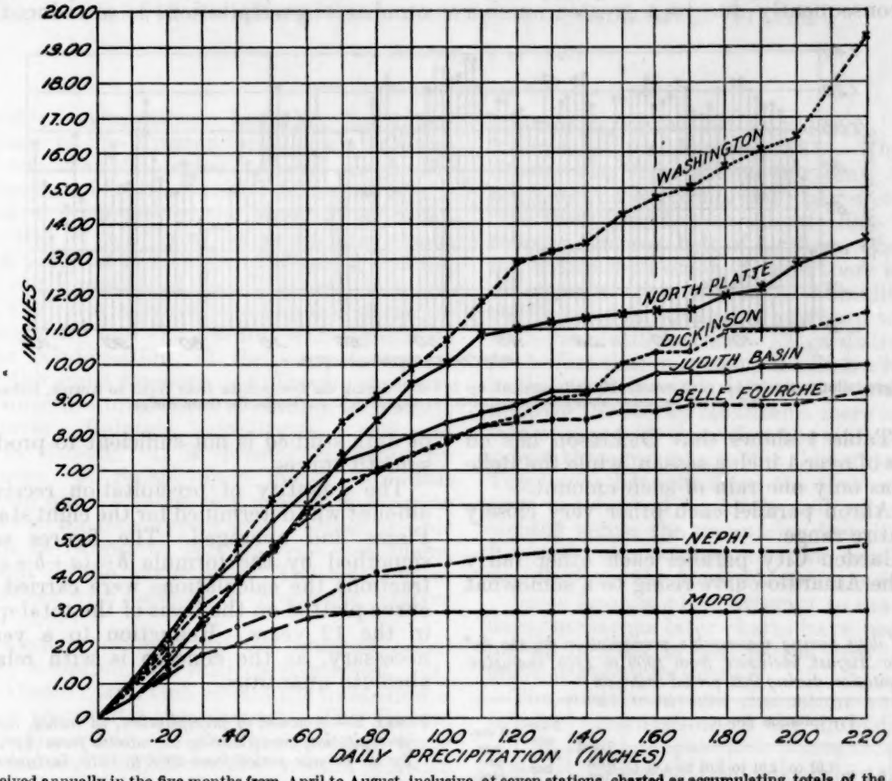


FIG. 1.—Precipitation received annually in the five months from April to August, inclusive, at seven stations, charted as accumulating totals of the quantities received in daily precipitations of different magnitudes.

One of the striking points shown in comparisons in the Great Plains is the comparatively small number of days having over 1 inch of precipitation at the Judith Basin and Belle Fourche stations. Another point is the comparatively large number of days having precipitation between 0.51 inch and 1 inch at Hays and North Platte.

Washington, D. C., has precipitation on a greater number of days than any station in the Great Plains, but it owes the greater part of its higher precipitation to an increase in the number of precipitation days of over 1 inch. The frequency of precipitation is only 17 per cent greater at Washington than at the Judith Basin station, but the quantity is 91 per cent greater.

The Nephi, Utah, and Moro, Oreg., stations each has a comparatively small number of precipitations, a small number or none of the larger quantities, and a small total.

Because so large a proportion, 82 per cent in the Great Plains, of the precipitations came within the one group in Figure 1 for as many stations as can be shown without too much confusion of the curves. On account of the small number of precipitations amounting to more than 2 inches a day this study was carried only to that point, and quantities above it were included in single entries.

Moro, Oreg., in a region of winter rainfall, receives during the summer months less precipitation in each unit group than any of the other stations and receives none in daily quantities above 0.80 inch. Nephi, Utah, also in a region of winter rainfall but with a higher annual and summer precipitation than Moro, receives more in each group than that place but generally less than any of the stations in the Great Plains. In quantities of more than 1.30 inches a day it had during the period under study only one precipitation of 2.61 inches.

The precipitation of six of the stations in the Great Plains (Judith Basin, Dickinson, Belle Fourche, Akron, Garden City, and Amarillo) is much the same when

considered in contrast to that at Hays and North Platte in the Great Plains, Washington, D. C., and Nephi and Moro in the intermountain area. There are, however, important differences between these six stations both in total quantity and in its distribution. In precipitations up to 0.60 inch a day the Judith Basin station receives more precipitation than any other of the Great Plains stations and only 0.73 inch less than Washington, D. C. The precipitation in quantities up to this amount, however, constitute nearly 64 per cent of the total at the Judith Basin station and only 37 per cent at Washington. Dickinson and Belle Fourche parallel each other very closely up to quantities of 1.20 inches. In rainfalls above that quantity daily Belle Fourche receives an average of only 0.87 inch a season, while Dickinson receives 2.99 inches. The higher seasonal precipitation at Dickinson is consequently due to a greater number of heavy rains. Table 1 shows that Dickinson has an average of 2½ rains of over 1 inch a season, while the Belle Fourche station has only one rain of such amount.

Dickinson and Akron parallel each other very closely throughout the entire range.

Amarillo and Garden City parallel each other fairly closely but with the Amarillo curve rising to a somewhat higher total.

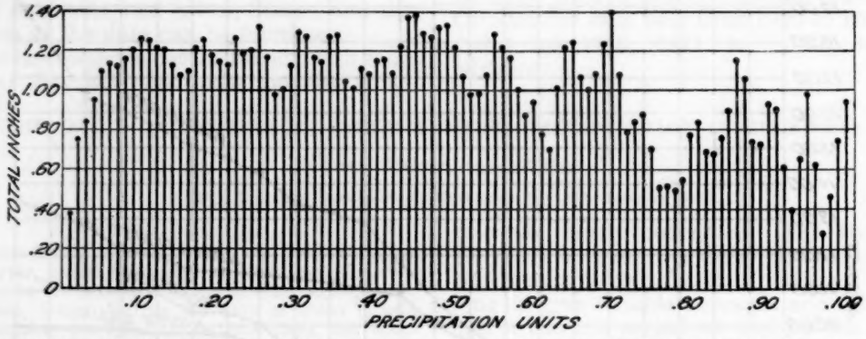


FIG. 2.—Total quantity of precipitation received in each measurable daily amount up to 1 inch during the five months from April to August, inclusive, in the 12 years from 1908 to 1919, inclusive, shown as the smoothed average of eight stations in the Great Plains.

TABLE 1.—*Number of days having measurable precipitation in the five months from April to August, inclusive, from 1909 to 1919, inclusive and the average precipitation during that period each year.*

Station.	Precipitation group.						Total number.	Average number per year.	Average precipitation.
	0.01 to 0.50 inch.	0.51 to 1 inch.	1.01 to 2 inches.	2.01 to 3 inches.	3.01 to 4 inches.	4.01 to 5 inches.			
									Inches.
Judith Basin, Mont.	506	50	14	1	0	0	571	47.6	10.12
Dickinson, N. Dak.	431	56	28	1	1	0	517	43.1	11.54
Belle Fourche, S. Dak.	450	53	10	2	0	0	515	42.9	9.27
North Platte, Nebr.	379	89	24	2	1	0	495	41.3	13.64
Akron, Colo.	416	58	22	5	1	0	502	41.8	11.89
Hays, Kans.	399	76	33	5	1	1	515	42.9	14.78
Garden City, Kans.	366	50	23	1	0	2	442	36.8	10.98
Amarillo, Tex.	348	65	25	3	1	0	442	36.8	11.92
Washington, D. C.	530	76	51	11	2	0	670	55.8	19.35
Nephi, Utah.	285	25	4	1	0	0	315	26.3	4.96
Moro, Oreg.[1]	251	11	0	0	0	0	262	21.8	3.03

[1] The data at Moro are for the 12 years from 1910 to 1921, inclusive.

North Platte and Hays have higher seasonal precitation than the other stations. Their greatest departure from the other stations is in the zone of precipitations from 0.60 inch to 1.10 inches a day. At these two stations the quantity received in each group of 0.10 inch remains fairly constant up to 1.10 inches. The differences between the two may be significant or may be due to insufficient data to smooth the curves. In rainfall received in quantities of 1.10 inches or less daily they average only about 1 inch each season less than Washington, D. C., but in quantities above that amount Washington receives enough more to bring its average for the five months up to 19.35 inches, as compared with 14.78 inches at Hays and 13.64 inches at North Platte.

The groups of 0.10 inch afford an analysis more refined, perhaps, than is necessary for agricultural purposes, but while the data were in hand they were subjected to further study to determine the contribution of each measured unit of 0.01 inch precipitation a day to the total. The concern in this study was primarily with the smaller quantities, because as an average of the eight stations in the Great Plains 45 per cent of the days having measurable precipitation have precipitation of not over 0.10 inch. The study was carried to quantities of 1 inch. Even before this quantity is reached the number of precipitations is so reduced that the volume of data studied is not sufficient to produce satisfactorily smooth curves.

The quantity of precipitation received in each unit amount was determined for the eight stations in the Great Plains and averaged. The figures so obtained were smoothed by the formula $b=(a+b+c)\ /\ 4$. To avoid fractions the calculations were carried through and the curve plotted on the basis of the total quantities received in the 12 years. Reduction to a yearly basis is not necessary, as the concern is with relative rather than absolute quantities.

TABLE 2.—*Amount of precipitation, in inches, received annually in each precipitation group during the months from April to August, inclusive, for the 12-year period from 1908 to 1919, inclusive.*

Precipitation groups.	Judith Basin.	Dickinson.	Belle Fourche.	North Platte.	Akron.	Hays.	Garden City.	Amarillo.	Great Plains average.	Washington.	Nephi.	Moro.[a]
0.01 to 0.10..	1.08	0.91	0.99	0.72	0.91	0.69	0.74	0.62	0.83	0.98	0.63	0.55
.11 to .20..	1.31	.91	1.10	.90	.97	.92	.78	.88	.97	1.23	.78	.70
.21 to .30..	1.15	.84	1.08	1.16	.96	1.03	.88	.82	.99	1.39	.79	.55
.31 to .40..	1.01	1.16	.70	.89	.76	1.04	1.11	.89	.95	1.36	.38	.32
.41 to .50..	1.05	.91	.95	1.16	1.04	1.39	.84	1.15	1.06	1.26	.38	.37
.51 to .60..	.86	1.11	.84	1.20	.70	.73	.68	.98	.89	.98	.27	.37
.61 to .70..	.89	.92	.76	1.35	.60	1.04	.66	1.10	.92	1.21	.54	.11
.71 to .80..	.31	.25	.64	1.06	.63	.69	.37	.76	.59	.74	.38	.06
.81 to .90..	.36	.50	.42	1.07	1.00	1.27	.50	.50	.70	.78	.14	0.00
.91 to 1.00..	.39	.32	.39	.55	.65	.95	.80	.40	.56	.81	.08	0.00
1.01 to 1.10..	.26	.53	.44	.79	.79	.87	.27	.62	.57	1.04	.17	0.00
1.11 to 1.20..	.19	.20	.09	.19	0.00	.48	.57	.19	.24	1.15	.10	0.00
1.21 to 1.30..	.42	.52	.11	.21	.21	.42	.11	.10	.26	.32	.10	0.00
1.31 to 1.40..	0.00	.11	0.00	.12	.45	.56	.34	.23	.23	.22	0.00	0.00
1.41 to 1.50..	.12	.85	.24	.12	.24	.24	.36	.49	.33	.85	0.00	0.00
1.51 to 1.60..	.39	.39	0.00	.13	.39	.77	.13	.39	.32	.51	0.00	0.00
1.61 to 1.70..	0.00	0.00	.14	0.00	0.00	.14	.28	0.00	.07	.28	0.00	0.00
1.71 to 1.80..	0.00	.59	0.00	.45	0.00	0.00	.15	.73	.24	.58	0.00	0.00
1.81 to 1.90..	.16	0.00	0.00	.15	.30	0.00	.31	.15	.13	.46	0.00	0.00
1.91 to 2.00..	0.00	0.00	0.00	.66	0.00	0.00	.17	0.00	.10	.33	0.00	0.00
2.01 up.....	.17	.52	.38	.76	1.29	1.55	.93	.92	.82	2.87	.22	0.00
Total:.	10.12	11.54	9.27	13.64	11.89	14.78	10.98	11.92	11.77	19.35	4.96	3.03

[a] The data at Moro are for the 12 years from 1910 to 1921, inclusive.

The results are plotted in Figure 2 by verticals raised from each amount to the quantity, as indicated by the marginal scale, received from it in 12 seasons. It will be noted that amounts from 0.05 inch to 0.70 inch per day contribute approximately equal quantities to the total precipitation. In other words, within these limits the frequency of precipitation is inversely proportional to its quantity. In a period having 20 days of 0.05 inch precipitation each there will be 10 days of 0.10 inch, 5 days of 0.20 inch, 4 days of 0.25 inch, and so on. The number of precipitation days below 0.05 inch increases with decreasing quantities but not in the same proportion. Table 2 and Figure 1 show that the upper limit of 0.70 inch to which this relation is limited is the minimum in the Great Plains and does not apply to all stations. At North Platte and at Hays the point at which the curve breaks is reached at 1.10 inches, and at Washington, D. C., at 1.20 inches. On the other hand, the critical point in the curve is reached at 0.30 inch at both Moro and Nephi.

The marked depression in the smoothed curve at 0.60 inch is due to the fact that some of the stations did not receive precipitation in quantities of 0.59 inch, 0.61 inch, and 0.62 inch.

Above the critical point, which varies with the station, the decrease in the frequency of precipitations is more rapid than increase in quantity, so that the product of the number of precipitations in a given time and their amount is a constantly decreasing quantity.

NOTE ON ATMOSPHERIC HUMIDITY IN THE UNITED STATES.

By ROBERT DE C. WARD.

[Harvard University, Cambridge, Mass., Oct. 21, 1922.]

Relative humidity.—Atmospheric humidity has many important relations to life—human, animal, and vegetable. It, to a considerable degree, affects our bodily comfort; our feeling of heat or cold. It is one of the controlling climatic influences in the growth and develment of crops and of all forms of plant life. Both directly and indirectly, it affects many of our activities, our industries, our commercial organization. Relative humidity, i. e., the ratio between the amount of moisture in the atmosphere and the amount which could be present, without condensation, at the same termperature and under the same pressure, is a direct expression of the physical moisture or dryness of climate in relation to its temperatures. Relative humidity is a real and definite factor in climate. It is directly indicated by organic substances. It reacts upon them. For this reason the human hair is commonly used in measuring relative humidity in the hair hygrometer. Other organic substances, such as catgut or certain vegetable fibers, may also be used in the same way. The cracking or swelling of woodwork with decrease or increase in relative humidity is well known.

The general system followed by the lines of equal relative humidity is simple, and easily remembered. (1) On the Pacific, Atlantic, and Gulf coasts the lines show a distinct tendency to parallel the seacoast. This feature is most clearly indicated on the Pacific slope, and there in the warmer months. (2) Over the interior plateau the lines group themselves in a general oval pattern around central or southern centers of minimum humidity. (3) Over the Great Plains lines of equal relative humidity lie more or less parallel with the meridians, especially in the central and southern sections. The geographical distribution of relative humidity, thus briefly outlined, depends on a number of controls. Among these (1) the temperature, (2) the direction of the prevailing winds, (3) the distance and direction of the chief source of moisture-supply, and (4) the topography are the most important.

The meridional trend of the relative humidity lines on the Great Plains was discovered by Loomis in 1880 in connection with his construction of the first chart of this kind for the United States.[1] The data upon which this pioneer chart was based related to a very few stations between latitudes 45° and 30° N., east of the Rocky Mountains, for January, 1875. Only four lines were drawn, viz, those for 50 per cent, 55 per cent, 60 per cent, and 65 per cent, but they were sufficient to indicate that "on the east side of these (Rocky) mountains there is a narrow belt of territory where the mean humidity is less than one-half; and there is a belt at least 400 miles wide where the mean humidity is less than two-thirds; and in advancing eastward we find the humidity to increase still further." This distribution is attributed to the fact that in crossing the Sierra Nevada the moisture, in the westerly winds, is "mostly condensed." "By passing over the Rocky Mountains there is a further condensation of vapor, so that when the air descends on the eastern side of these mountains it is almost destitute of moisture." The vapor brought from the Gulf of Mexico is diffused over the central lowlands and mixes with the dry air coming across the mountains from the west. Hence, in Loomis's opinion, the relative humidity must increase rapidly from the Rocky Mountains eastward.

Since Loomis's first attempt to draw relative humidity lines, numerous later charts have been published, covering all months as well as the year, and based on more and more complete data.[2]

The most complete discussion and cartographic and tabular presentation of the humidity element in the

[1] Elias Loomis: "Contributions to Meteorology, Being Results Derived from an Examination of the Observations of the United States Signal Service and from Other sources." *Amer. Journ. Sci.*, 3d ser. vol. 20, 1880, pp. 1–21. Pl. I.

[2] See, e. g., the following:

Frank Waldo: "Elementary Meteorology." 8 vo. New York, 1896. Fig. 114 shows average annual relative humidity in the United States, but no statement is made as to the source of the chart or the period covered by the observation.

H. A. Hazen: "The Distribution of Moisture in the United States." *Ann. Rept. Chief of Weather Bureau for 1897–98.* 4 to. Washington, D. C., 1897, pp. 327–338; pls. VI, VII, diagrs. V–IX. The plates illustrate "waves of moisture, pressure, and temperature" for individual dates; the diagrams show fluctuations of dewpoint, of dewpoint and temperature, and diurnal range of moisture.

Frank H. Bigelow: "The Vapor Tension on the Sea Level, the 3,500-foot and the 10,000-foot Planes." *Ann. Rept. Chief of Weather Bureau for 1900–1901.* 4 to. Washington, D. C., 1902. Vol. II, pp. 420–422. Gives monthly and annual charts of relative humidity at sea level, and monthly and annual charts of normal vapor tension at sea level and on the 3,500-foot and the 10,000-foot planes.

Annual Report of the Chief of the Weather Bureau for 1901–02. 4 to. Washington, D. C. 1902, pp. 317–320. Three charts of normal relative humidity for January, July, and the year, based on data covering varying periods of time, from 4 to 14 years. Data given in tables. No author's name given, and no discussion.

Kenneth S. Johnson: "Mean Monthly and Mean Annual Relative Humidity Charts of the United States," *Rept. So. Afr. Assoc. Adv. Sci.*, 1906. 8 vo. Cape Town, 1907, pp. 161–168. Contains mean annual and mean monthly charts of relative humidity, based chiefly on the period 1888–1901, although in some cases shorter records were taken into account but given less weight. The data were not reduced to the true daily mean. Lines are drawn for differences of 10 per cent.

For tabulations and discussion of relative humidity data see, in addition to the above, the following:

W. B. Stockman: "Temperature and Relative Humidity Data." *U. S. Weather Bureau, Bulletin O.* 4 to. Washington, D. C., 1905. Pp. 29.

Alfred J. Henry: "Climatology of the United States." *U. S. Weather Bureau Bulletin.* Q4 to. Washington, D. C., 1906. p. 61. Table VIII, pp. 106–109, contains the monthly mean values of relative humidity for 8 a. m. and 8 p. m., seventy-fifth meridian time, for a number of selected stations.

United States, based on the latest and most reliable data, is that of Preston C. Day, Chief of the Climatological Division of the Weather Bureau.[3]

With the exception of one set of maps [4] all the charts included in Day's monograph are to be found in the latest publication on humidity in the United States, the section on *Precipitation and Humidity* of the *Atlas of American Agriculture*.[5] In the *Atlas* the charts are on a smaller scale, and reproduced in colors, and a somewhat different selection of stations is made for purposes of illustrating, by means of curves, the annual march of humidity and vapor pressure.[6]

It is impossible to show the distribution of relative humidity over the United States satisfactorily and accurately by means of charts showing the mean monthly values, as can be done in the case of temperature or of rainfall. The most extensive series of observations available for about 200 regular Weather Bureau stations cover the period 1888–1913, and relate to 8 a. m. and 8 p. m., 75th meridian time (figs. 91–98, in *Atlas*). But the mean of such twice-daily observation does not always give the true daily mean, and the data are not strictly comparable for all parts of the country because of the difference in local time at which the observations were made, 8 a. m., 75th meridian time being 5 a. m. Pacific time.

To the west of the Rocky Mountains the 8 a. m. readings are found to approach the maximum for the day, and the 8 p. m. approach the minimum, the average of the two being close to the 24-hour mean. In the east, however, the 8 a. m. observations give values considerably higher than the daily means, and those for 8 p. m. are appreciably lower. With progress westward, owing to the earlier local time, the departures from the daily means become increasingly greater. The only extensive series of observations made at the same hour of local time (2 p. m.) covers the 5-year period, 1876–1880, for about 90 stations (figs. 85–88, in the *Atlas*, show the average relative humidity at 2 p. m., local time, for January, April, July, and October). But the period is short, the observations were not as carefully made as at present, and the psychrometric tables there used were not as accurate as those now employed. Hence the data are not considered to be directly comparable with averages for longer periods and for later years. It is pointed out that the 2 p. m. average relative humidity is not very different from the average minimum for the 24-hour period, the minimum, however, usually coming later than 2 p. m. and being a little lower. It is only in recent years that hygrograph records have been available for some Weather Bureau stations. With these exceptions, no direct observations of the daily minimum relative humidity have been made. For this reason the average daily minimum relative humidity has been computed for April, July, and October from the average 8 p. m., 75th meridian time, vapor pressure, and the saturation pressure corresponding to the average daily maximum temperature (figs. 98–101, *Atlas*). The lowest average daily minimum relative humidity is shown to be less than 15 per cent in southern Arizona, southwestern New Mexico, and extreme southwestern Texas in April. In July, as most of the Southern Plateau has less than 20 per cent, the highest values for the average minimum relative humidity are over 70 per cent on the extreme northwestern coast of Washington and at Cape Hatteras in July and in October, and over the eastern part of Cape Cod in October.[7]

The essential facts regarding the geographical distribution of mean annual relative humidity over the United States are shown in Figures 1–4. These are redrawn from the corresponding charts in the *Atlas of American Agriculture*, section on *Precipitation and Humidity*.

A belt of uniformly high relative humidity along the coasts averages about 75–80 per cent, and at certain seasons even exceeds 90 per cent on the North Pacific coast. This belt, from which there is a well-marked decrease inland, is in striking contrast with the far southwestern interior, in the lee of the Sierra Nevada Mountains, where the mean annual values are 50 per cent and even lower over parts of Nevada, Utah, Arizona, New Mexico, and southeastern California. The high humidities on the coast remain fairly constant throughout the year. The minima in the Great Basin, on the other hand, become distinctly more marked during the hot summers of that region, reaching 30 per cent and even 20 per cent over the districts of most extreme aridity. This seasonal change is clearly indicated in the annual migration of the lines of relative humidity. These travel northward as summer comes on, reach their northernmost limits in June or July, and then return southward again. Some of them even disappear entirely from the map in winter. Another striking effect of this seasonal variation is seen in the marked increase in summer of the relative humidity gradient between the damp southern Pacific coast and the interior deserts, east of the mountains.

Most of the eastern United States, inland from the coast and east of the Great Plains, runs about 70 to 75 per cent, with not very much seasonal variation. The plateau districts average, as a whole, some 10 to 20 per cent lower, with the seasonal changes just noted. The Plains are intermediate between the damper eastern and the drier southwestern sections. The distortion of the lines in the vicinity of the Great Lakes shows that these large bodies of water have similar effects to those of the oceans in increasing the relative humidity (75–80 per cent). This effect can be seen where stations on the lee side of one of the Lakes are compared with others on the windward side. Thus, Grand Haven, Mich., has a mean annual relative humidity of 78 per cent. Milwaukee, Wis., on the opposite shore of Lake Michigan, has 75 per cent. Davenport, Iowa, and St. Paul, Minn., farther west, have 72 per cent.[8]

[3] Preston C. Day: "Relative Humidities and Vapor Pressures over the United States, Including a Discussion of Data from Recording Hair Hygrometers." MONTH. WEA. REV., SUPPL. No. 6. 4 to. Washington, D. C., 1917. Pp. 61; charts; diagrs. The following relative humidity charts are included: Average relative humidity for January, April, July, and October at 8 a. m. and 8 p. m., 75th meridian time (25-year period, 1889 to 1913, inclusive); for January, April, July, and October at 3 and 11 p. m., 75th meridian time (period 1882–1885, inclusive); for January, April, July, and October at 2 p. m., local time (period 1876–1880, inclusive); average minimum relative humidity for April, July, and October (computed from the mean vapor pressure at 8 p. m., 75th meridian time, and saturation pressure for the mean daily maximum temperature). The diurnal and annual variation are shown by curves for selected stations and for different seasons. There are also charts showing the average depression of the wet bulb at the time of the daily maximum temperature for April, July, and October. These are to be discussed by the writer in a later article. The absolute humidity charts are considered at the end of the present paper. The set of "Climatic charts of the United States, published by the Weather Bureau, includes four charts showing lines of equal mean relative humidity for 8 a. m. and 8 p. m., 75th meridian time, for January and July. The observations used were those made at regular Weather Bureau stations during the 25-year period 1889–1913, inclusive, this period being the same as that in Day's charts.

[4] Those for 3 and 11 p. m. for January, April, July, and October.

[5] *Atlas of American Agriculture*. Prepared under the supervision of O. E. Baker, Agriculturist. Part II, Climate. Contribution from the U. S. Weather Bureau. Charles F. Marvin, Chief. Section A, Advance Sheets No. 5. *Precipitation and Humidity*. Prepared under the direction of F. C. Day, Climatologist, by J. B. Kincer, fol. Washington, D. C., 1922, pp. 45–47; figs. 85–100. Three charts showing the average depression of the wet-bulb temperature at the time of minimum relative humidity in April, July, and October will be discused in a later paper by the present writer.

[6] Compare Day's figs. 1–3 with fig. 89 of the *Atlas* section.

[7] The values for January were not computed, because of (1) the large temperature variability and (2) the frequency of temperatures below freezing.

[8] C. H. Eshleman: "Climatic Effect of the Great Lakes as Typified at Grand Haven, Mich." *Met. Chart of the Great Lakes* (U. S. Weather Bureau), Sept. 1913.

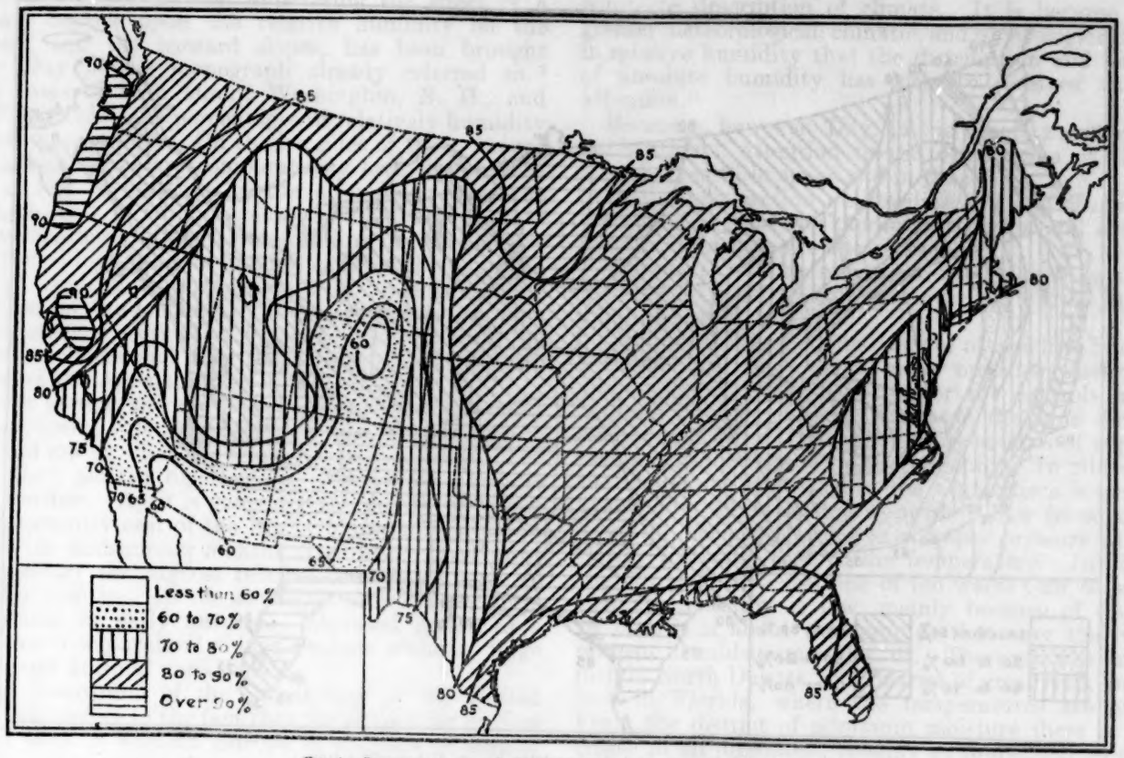


FIG. 1.—January average relative humidity, 8 a. m., 75th meridian time.

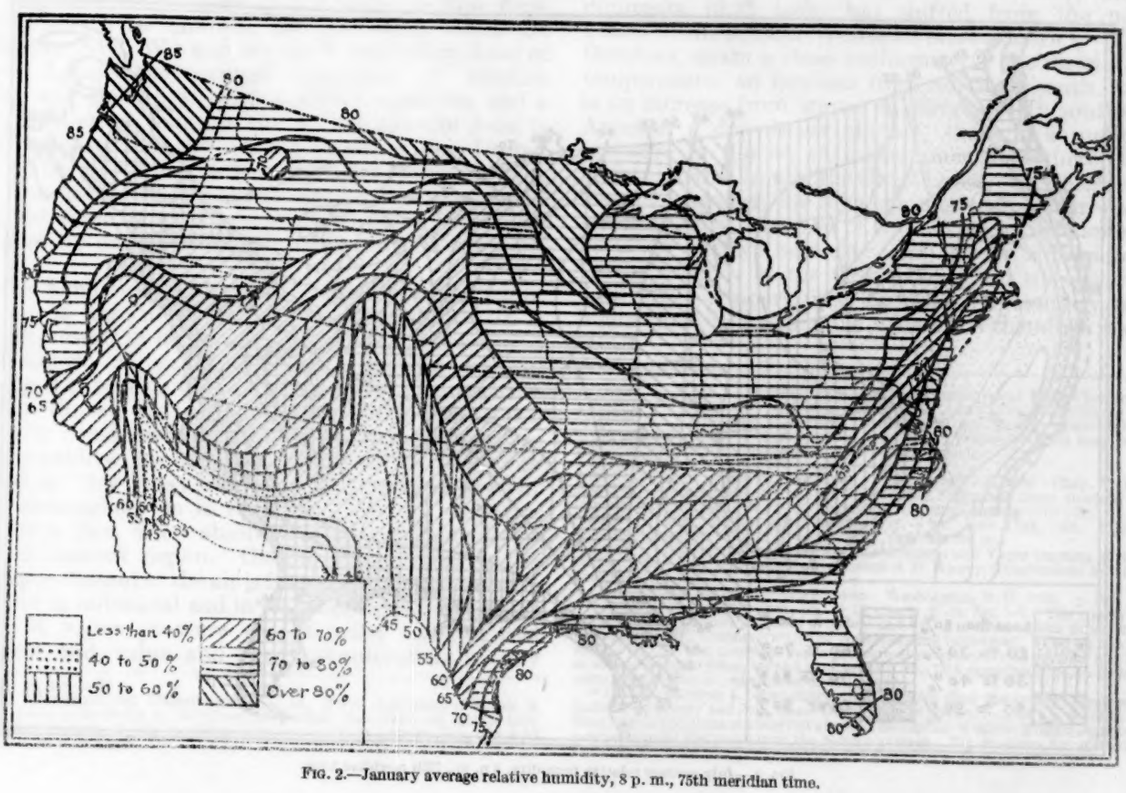


FIG. 2.—January average relative humidity, 8 p. m., 75th meridian time.

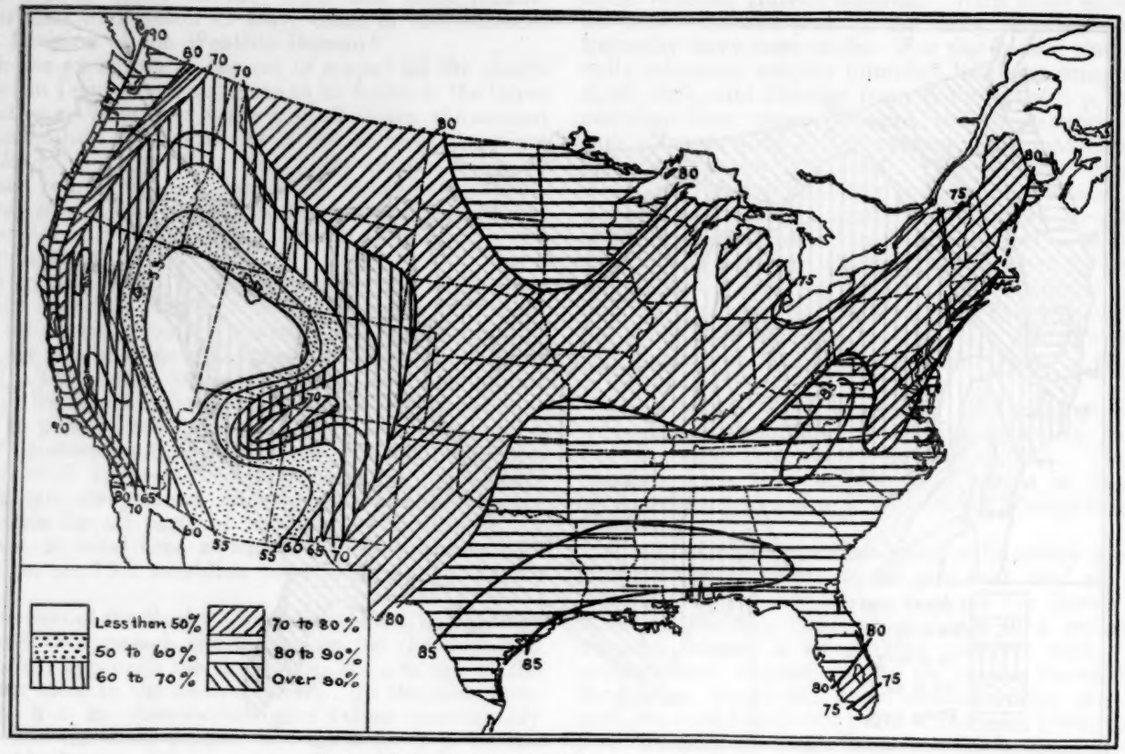


FIG. 3.—July average relative humidity, 8 a. m., 75th meridian time.

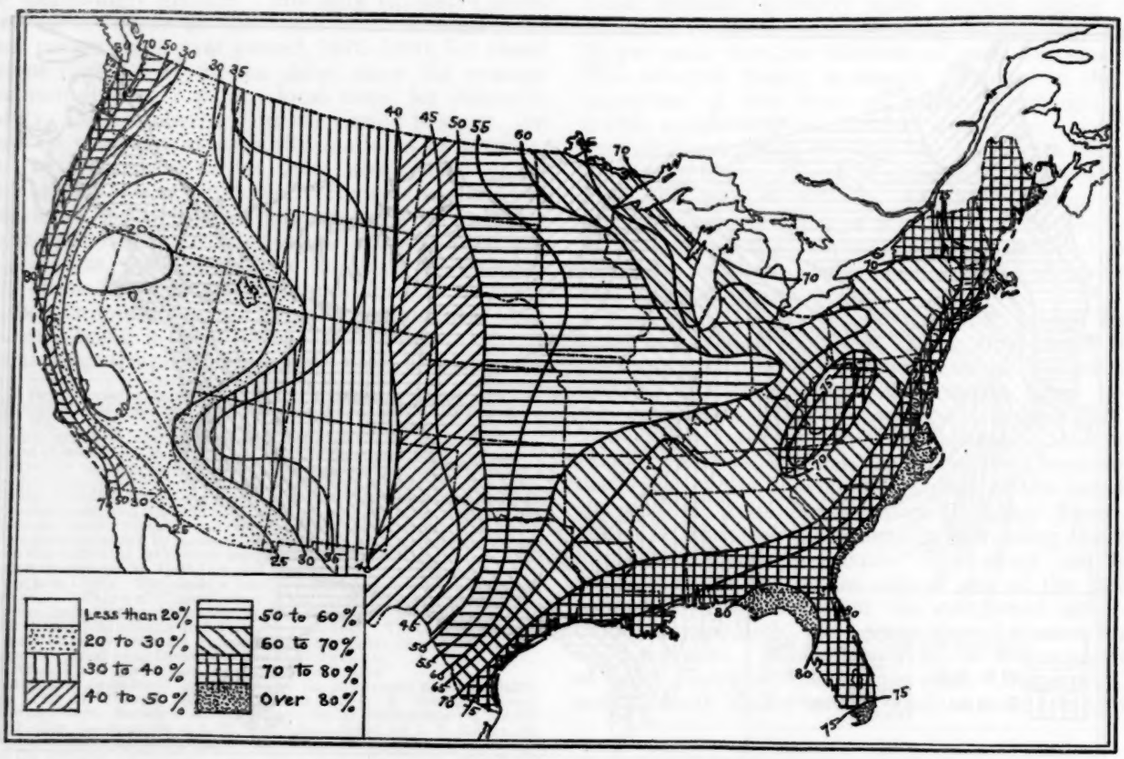


FIG. 4.—July average relative humidity, 8 p. m., 75th meridian time.

Another interesting fact, illustrating the effect of a mountain barrier upon the relative humidity on the windward and the leeward slopes, has been brought out by Day in the monograph already referred to.[9] In the cases of both Mount Washington, N. H., and Pikes Peak, Colo., the percentages of relatively humidity are continuously high. On the lee sides of these mountains the humidities are comparatively low, the obvious result of loss of moisture in the air passing over the mountains and of the decrease in humidity due to adiabatic warming of the air descending on the leeward side. Hence high relative humidities are to be expected generally on the windward sides of mountains and low values on the lee sides. These conditions are seen over the eastern sections of Colorado and Wyoming on the winter charts and also less clearly in the district just east of the Appalachians.

In both annual and diurnal periods relative humidity is, as a general rule, highest when the temperature is lowest and lowest when the temperature is highest. The curves when plotted together are directly the opposite of one another. April is generally the month of lowest relative humidity east of the Rocky Mountains, while to the west the midsummer months are driest. Over most of the country the highest relative humidities come in the colder months. In the southeast they may occur in late summer or early autumn. Elevated areas, as a rule, have comparatively high values without large seasonal and diurnal variations.

In his description of the climatology of the United States Hann refers to the fact that the air is drier in New England than in western Europe in districts of similar mean annual temperatures, a point first emphasized by Desor.[10] This lower humidity is explained as the result of the prevalence of offshore (NW.) winds in New England in winter. In summer, the prevailing winds are also offshore (SW., W.) and are much drier than those of Europe. Again, the annual variation of relative humidity and cloudiness, with a winter minimum and a summer maximum, found in the eastern coast of Asia, is not characteristic of the eastern coast of the United States. The prevailing winter offshore winds in the North American Atlantic coast are less emphatic and less regular than those of eastern Asia, being frequently interrupted by damp easterly cyclonic indrafts from the ocean.

Absolute humidity.—The actual amount of water vapor in the air is known as the absolute humidity. It is usually expressed in decimals of inches of pressure, and is then known as vapor pressure. Another way of expressing it is to give the actual weight of the moisture present in the air as so many grains in a cubic foot. Climatically considered, absolute is not as significant as relative humidity, for climates which are distinctly to be classed as "dry" may have as much moisture present in their atmosphere as is found in "moist" climates. Desert air is thus often absolutely moister than the air in a much damper region. On the other hand, as the actual vapor content of the air is frequently of considerable importance in industrial and in engineering undertakings, the data of vapor pressure are in many cases of real significance and value and need consideration in any complete description of climate. It is because of the greater meteorological, climatic, and physiological interest in relative humidity that the distribution and variation of absolute humidity has hitherto received the least attention.[11]

Recently, however, Day, in the report above referred to, has given attention to the distribution of absolute humidity, both in space and in time.[12]

In the new section on *Precipitation and Humidity* of the *Atlas of American Agriculture* charts and curves of absolute humidity are also included.[13]

Figures 5 and 6 redrawn from the *Atlas*, show the distribution of absolute humidity over the United States in January and in July.

Temperature is the chief control of absolute humidity. Therefore the lines of equal vapor pressure closely follow the isotherms. Other less important controls are the distance from large bodies of water, the wind direction, whether it be from or toward those sources of supply of vapor, and the intervening topography. In midsummer the amount of moisture in the atmosphere is generally from 2 to 4 times as large as in midwinter (compare figs. 5 and 6), the seasonal curve of vapor pressure as a rule closely following that of the temperature. In January (fig. 5), with the exception of the warm Gulf coasts, the absolute humidity is low, mainly because of the cold. In fact, it is about the same as that over the interior plateau in midsummer (fig. 6). The extremes are 0.05 inch in North Dakota, in a district of great cold, and 0.55 inch in Florida, where the temperatures are highest. From the district of minimum moisture there is an increase in all directions, roughly in proportion to the increasing temperatures. In July (fig. 6) the Gulf coast again has the maximum (about 0.85 inch), while the minimum (0.25 inch) has shifted from the northern Plains to the interior Western Plateau district. There is, therefore, again a close conformity to the distribution of temperature: an increase from north to south, as there is an increase from winter to summer. In southwestern Arizona, a dry desert climate, there is actually more moisture in the air in midsummer than there is in the moist climates around the Great Lakes. In the first-named district, however, the high summer temperatures and the resulting large capacity of the air for water vapor result in a low relative humidity, and the air is therefore dry. In the vicinity of the Great Lakes, on the other hand, with lower temperatures, the relative humidity is much higher than in Arizona, and the air is therefore relatively moist.

[9] P. C. Day, *loc. cit.*, p. 10.

[10] J. Hann: "Handbuch der Klimatologie," 3d ed. 8 vo. Stuttgart, 1911, vol. 3, pp. 386–387. Desor pointed out in 1852 (*Proc. Boston Soc. Nat. Hist.*, vol. 4, 1851–1854, pp. 183–184) that because of this condition furniture made in Europe does not hold together well in New England.

[11] See e. g., H. H. C. Dunwoody: "Absolute Humidity and Mean Cloudiness in the United States represented by Tables and Charts." *Ann. Rept. Chief Signal Officer for 1884.* 8 vo. Washington, D. C. 1884. Appendix 9, pp. 123–129. Contains four charts of the seasonal distribution of absolute humidity in grains per cubic foot, based upon the observations of 1883 at regular Signal Service stations.

F. H. Bigelow: *loc. cit.*, footnote 2.

A. W. Greely: "American Weather." 8 vo. New York, 1888. Chap. V (Humidity and Evaporation) contains Charts XVIII and XIX showing mean absolute humidity in grains per cubic foot for January and July, based on data for 1876–1886.

Frank Waldo: "Elementary Meteorology." 8 vo. New York, 1896. Figs. 112, 113. The same charts as those of General Greely, just referred to.

Frank H. Bigelow: "Report on the Temperatures and Vapor tensions of the United States, reduced to a Homogeneous System of 24 Hourly Observations for the 33-year Interval, 1873–1903."

U. S. Weather Bureau Bulletin S. 4 to. Washington, D. C., 1909. p. 302.

[12] P. C. Day: *Loc cit.* Text, pp. 10-12; charts 27-34; figs. 1-6. The charts show the average vapor pressure in inches at 8 a. m. and 8 p. m., 75th meridian time, for January, April, July, and October (with the corresponding isotherms). The figures show the annual and diurnal march of vapor pressure at several selected stations and the ratios of the mean vapor pressures at 8 a. m. and 8 p. m., 75th meridian time, to their bihourly means for local standard time at three stations.

[13] *Loc. cit.*, footnote 4. Two charts (figs. 102, 106) show the average vapor pressure in inches for January and July, based on the mean of the 8 a. m. and 8 p. m. (75th meridian time) vapor pressures as observed at about 200 regular Weather Bureau stations. These means do not differ much from the 24-hour average. Fig. 89 shows, for selected stations, the annual march of vapor pressure. See also text, p. 45.

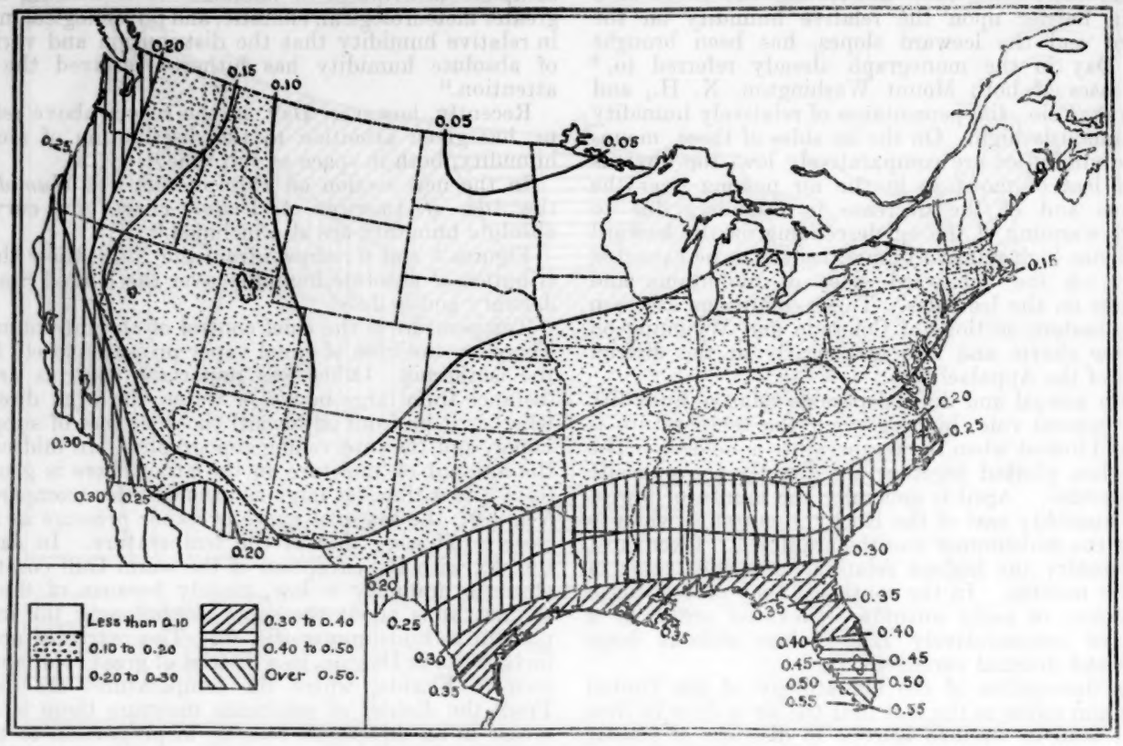


FIG. 5.—January average vapor pressure, in inches.

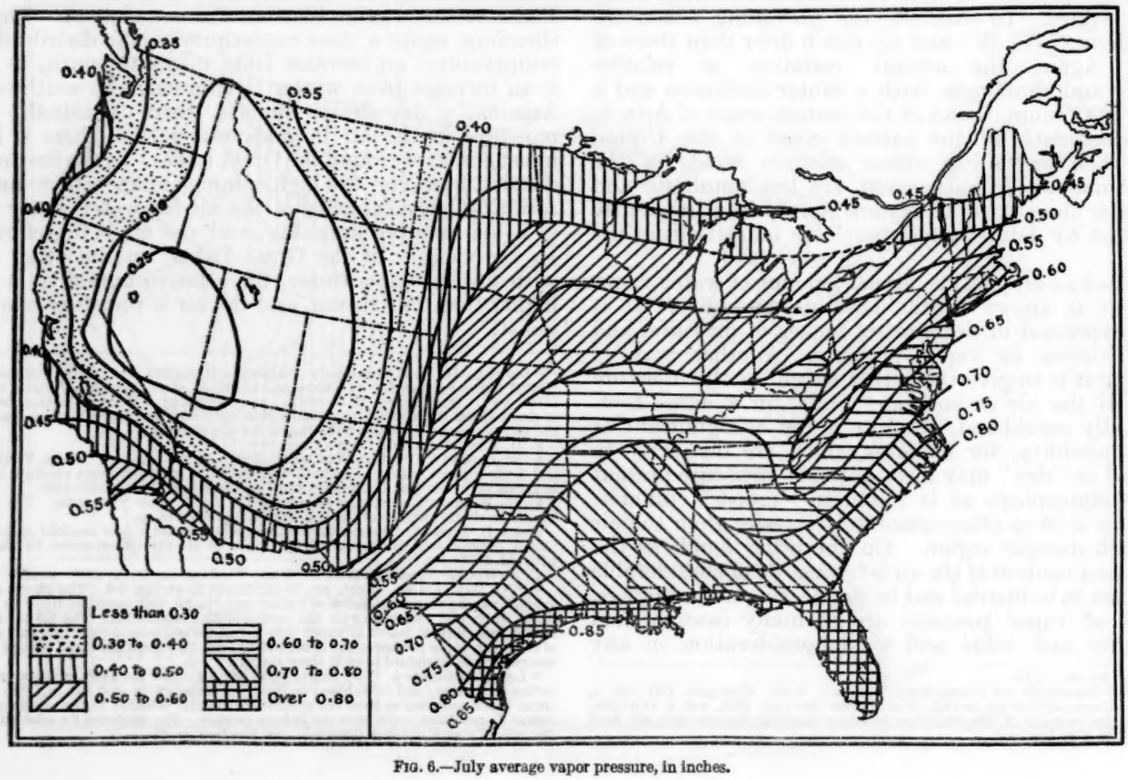


FIG. 6.—July average vapor pressure, in inches.

The diurnal variations in absolute humidity are chiefly dependent upon local conditions of evaporation from moist surfaces, and upon the balance between that source of supply of water vapor and any loss that takes place through condensation (dew, frost, etc.), all of these processes being largely under the control of temperature. Minima usually come at night, while maxima generally occur by day. All the interacting controls are subject to variations which depend upon permanent local conditions and upon temporary weather types.

CAUSE OF THE ACCELERATED SEA BREEZE OVER CORPUS CHRISTI, TEX.

By JOSEPH P. MCAULIFFE, Meteorologist.

[Weather Bureau, Corpus Christi, Tex., Sept. 12, 1922.]

SYNOPSIS.

The sea breeze at Corpus Christi attains unusually high velocities, becoming a fresh to strong southeast wind in the afternoon during summer. The same character of sea breeze is not to be found on either the northern or extreme southern Texas coast. The cause of this unusual sea breeze at this point is explained by reason of the topography of the hinterland of Corpus Christi and the contour of the coast line.

It has been established by observations extending over a period of 35 years and by comparison of average wind velocities on different parts of the Texas coast that the sea breeze attains unusually high velocities at Corpus Christi and its vicinity. This sea breeze comes from the southeast, usually begins after 8 a. m. and continues with increasing velocity during the day, frequently continuing as a moderate breeze throughout the night, but usually diminishing after midnight. It has an average velocity of 12 miles per hour at 10 a. m., when it usually becomes noticeable, and 19 miles per hour at 5 p. m., the time of its maximum force. By comparison with Galveston and Port Arthur it is readily seen that the sea breeze at Corpus Christi far surpasses the daily wind movement on the northern Texas coast. Comparison with places south of Corpus Christi has been impossible because of lack of data, but it is certain that no such wind velocities occur on the south Texas coast as those found near Corpus Christi.

While the average velocity of this breeze is remarkable, especially during the afternoon hours, the actual maxima attained are even more striking. Maximum velocities of 20 to 30 miles per hour, and sometimes higher, are frequent, due to nothing more than the natural flow of sea air landward. When accelerated by areas of low pressure in the interior, greater velocities are experienced. The regularity of this sea breeze is also remarkable; it is only during cloudy weather that it fails to be a fresh breeze.

The following tables show the average hourly velocities at Corpus Christi, Galveston, and Port Arthur during the three summer months of June, July, and August, and the average velocities at 10 a. m. and 5 p. m., the hours when the sea breeze has its average and maximum velocities, respectively.

TABLE 1.—*Average hourly wind velocity (miles per hour).*

	June.	July.	August.
Corpus Christi	14.2	13.3	13.3
Galveston	11.1	9.6	9.8
Port Arthur	9.2	7.7	7.1

TABLE 2.—*Average hourly wind velocity for 10 a. m. and 5 p. m.*

	June.		July.		August.	
	10 a. m.	5 p. m.	10 a. m.	5 p. m.	10 a. m.	5 p. m.
Corpus Christi	13	18	11	19	11	19
Galveston	11	12	8	12	9	12
Port Arthur	10	11	8	11	8	10

Period of observations in the above tables: For Corpus Christi and Galveston, 1911-21, inclusive; for Port Arthur, 1917-21, inclusive.

Tannehill [1] has shown that this high average wind velocity during the hottest part of the day in summer accounts for the deficient rainfall found on this coast, the continual movement of sea air landward with such great velocities preventing the formation of convectional thunderstorms upon which the summer rainfall mainly depends. It may be interesting to state that where this sea breeze begins to lessen, some 20 or 30 miles inland, thunderstorms are much more frequent than on the immediate coast. In the western part of Nueces County, near Robstown and Bishop, thunderstorms are relatively frequent during the summer months, and the formation of the thunder clouds can be plainly seen from Corpus Christi, and often thunder is heard, while clear skies are prevalent at the last-named place. Sometimes for several days in succession thunderstorms occur in the western part of the country while no rain falls on the coast. It is by no means an uncommon sight to see the air above Corpus Christi Bay perfectly clear, while convectional clouds completely cover the sky north and west of the station.

There are two causes for the increased sea breeze at Corpus Christi, viz:

1. The topography of the hinterland of Corpus Christi—a treeless plain, rising gradually and devoid of marshes.

2. The contour of the coast line at this point allowing the ocean air to reach the shore practically unimpeded.

Regarding the first cause of the abnormal sea breeze: To the north, west, and northwest of Corpus Christi lies a level prairie country, practically treeless, excepting scattered patches of mesquite. This plain increases gradually in elevation to the hilly country farther north. In the immediate vicinity of Corpus Christi for probably 30 miles inland is an ideal prairie land, about one-third under cultivation. There are no marshes in the vicinity.

When the sun's rays fall upon this plain it is heated abnormally, and there being no forests or marshes to absorb the heat or prevent its rapid radiation the natural consequence is an abnormal heating of the air immediately above. Isobaric surfaces are therefore unduly elevated, consequently the cooler ocean air flows in toward this area of barometric depression with great freedom, and of course the overflowing air from aloft assists in the circulation. On clear days the bare soil becomes so heated that this sea breeze continues far into the night, even after the time for the usual land breeze to begin. It is only on nights following days when the sea breeze has been usually weak that the typical land breeze asserts itself.

Regarding the second cause, which is of less importance: The curve in the coast line at Corpus Christi allows the southeast wind to strike the shore at such an angle that it meets with practically no resistance from a land surface before reaching the coast. It therefore comes over Corpus Christi with practically the same velocity that it has on the open ocean. To the south of this point the coast line is such that the east wind meets with

[1] I. R. Tannehill: "Wind Velocity and Rain Frequency on the South Texas Coast," MO. WEATHER REV., September, 1921.

least resistance, while on the northern coast the due south wind is the breeze that has least resistance. However, neither the east nor the south wind is the ideal sea breeze on this coast; it is the southeast wind that predominates, and this breeze finds least resistance at that part of the Texas coast between Baffins Bay and Matagorda Bay, with the greatest known velocities at Corpus Christi.

The physiological effects of this fresh breeze are pronounced. The fresh air of this locality is in marked contrast to some southern sea coasts, where stagnant coditions are frequent. Debilitating calms are relatively few on this coast, while the high-wind movement prevents that dampness and sultriness so dreaded in some subtropical regions.

In conclusion it may be said that the middle Texas coast has the swiftest and steadiest sea breeze to be found on this coast and that the land breeze is not present, except occasionally. This condition is explained by reason of the barren plains that form the hinterland of Corpus Christi, together with the favorable exposure of the place by reason of the curve in the coast line. While this increased sea breeze causes a diminution in the rainfall, it has its compensating features in the fact that a more comfortable climate is thereby created, and sultriness, sweltering heat, and damp conditions are lacking.

DOES THE FORMATION OF ABNORMALLY HEAVY ICE IN THE BERING SEA CAUSE FAMINE IN NORTHERN JAPAN? A REVIEW.

By J. B. KINCER.

Weather Bureau, Washington, D. C., October, 1922.]

By the usual custom of reasoning inductively from cause to effect, the average reader would, perhaps, have considerable difficulty in arriving at an affirmative answer to the above question. Winter scarcity or abundance of ice formation on rivers or large bodies of water concerns the American people chiefly from the viewpoint of personal or commercial convenience during the period of its prevalence and whether or not an adequate supply becomes available for storage purposes in sections where this custom obtains. To the people of Japan, however, the formation of ice in winter in the Bering Sea and neighboring waters has an entirely different and a deeper significance. Its presence in large or small amounts does not inconvenience them in winter nor do they give it a thought for summer use, but it does appear indirectly to largely control their food supply during the following year by the bearing it has on the summer temperatures on which the production of rice, in turn, depends, particularly in the northern portion of the Empire.

Rice is the dominant food crop of Japan. It normally occupies nearly one-half of the total cultivated land, with a value of about twice that of any other crop. The importance of this food to the people is very great, the per capita production being usually about 170 pounds. The high price of land and abundant labor favor an intensive form of cultivation and a product of high quality. Notwithstanding this, there is a large variation in production from year to year, especially in the north, where the summers are normally cooler than farther south. While rice is a tropical cereal thriving best in regions of high temperature and moist air, it is also grown well into the Temperate Zone, but is seldom successfully produced where the mean temperature during the four months of the active growing season is less than 75°. In Japan, however, it is cultivated northward to the 70° summer isotherm.

In this case, as in all others of like nature, where a tropical plant is grown at or near the limits of warmth requirement, the variation of temperature is of great importance, and usually determines in large measure the quantity production.

As an indication of the large variation of rice production in northern Japan, it may be mentioned that the standard deviation in yield in Hokkaido for the period from 1892–1919 was 32 per cent of the mean, expressed in koku per tan, corresponding in comparison to about 12 per cent in the production of corn in bushels per acre in our own State of Ohio. (One koku per tan is equal to about 2.1 American bushels per acre.) In recent times northern Japan had abnormally cool summers in 1902, 1905, and 1913, and in consequence these years saw great rice failures, with resulting very severe famine in most of that part of the Empire.

Owing to the fact that the prosperity of northern Japan depends so largely on the rice crop grown there and the further fact that rice production is so intimately related to the summer temperature, the question of causes for the variations in temperature has been given exhaustive study by meteorologists in that country. A paper on the subject by Dr. T. Okada, who is well and favorably known to many meteorologists in this country, was published in the *Journal of the Meteorological Society of Japan*, December, 1915, in which the relation of the intensity of the prominent centers of action, embodied in the winter Siberian HIGH and the Aleutian LOW and their counterparts, the summer Pacific anticyclone, and Asiatic depression, to the temperature in Japan was pointed out.[1] Later the same author pointed out the relation between the July temperature of our Pacific coast and that in Japan. He found in this case a negative relation between the temperature at San Francisco, Calif., and Erimo, Japan, represented by a correlation coefficient of -0.51 ± 0.10, when the variations in temperature from one year to the next were used as a basis for the computation. At the same time a rather high correlation was found between the barometric pressure in a number of western countries and the summer temperature in Japan.[2] In a succeeding note, several additional pressure-temperature relations were shown,[3] while there appeared in the *Bulletin of the Central Meteorological Observatory of Japan*, vol. 3, No. 1, 1919, a very interesting paper by Doctor Okada on the probabilities of forecasting by statistical methods the yield of rice in northern Japan from the several relations he had pointed out in his previous papers.

Up to this point Doctor Okada's studies had led to certain more or less definitely established, or suggested, relations between atmospheric conditions in different parts of the world and summer temperatures in Japan, but the meteorological explanation of these appeared rather involved, especially in view of their multiplicity. In a second paper on the possibility of forecasting the summer temperature and the approximate yield of rice in northern Japan, published in the *Memoires of the*

[1] This article was reprinted in the MO. WEATHER REV., January, 1916, 44: 17–21.
[2] MO. WEATHER REV., May, 1917, 45: 238–240.
[3] MO. WEATHER REV., November, 1917, 45: 535–538.

Imperial Marine Observatory,[4] which has just reached the Weather Bureau library, Doctor Okada has presented some very interesting conclusions.

Two distinct ocean currents bathe the eastern shores of Japan—the northern, or cold, current, "Oyashiwo," and the warm, southern current called "Kuroshiwo," or Japan Current. From observational and other data available it now appears that the summer temperature in northern Japan depends largely on the temperature of the former, "Oyashiwo," flowing southwestward from the Bering Sea and neighboring waters. It was but natural to assume that with abundant ice in the northern waters, which feed this current, it would be cooler in the summer season than when scanty ice prevailed there. But this assumption was difficult to verify because of the lack of ice data from the north. In this emergency, Doctor Okada took the winter temperature at Nemuro in northern Japan as an index of the winter temperatures farther north and correlated these with the yield of rice in northern Japan for the 28-year period from 1892–1919. He found a parallellism represented by the correlation coefficient $+0.55 \pm 0.09$. In view of the length of the period covered and the admitted inadequacy of the temperature data utilized, this shows a remarkably close relation.

Next, the cause of the occurrence of severe and mild winters in the Bering Sea was investigated. He states on this subject:

As is well known, the winter temperature of the northern waters is chiefly controlled by the inflow of cold air from eastern Siberia, which is a member of the system of cyclonic circulations around the semi-permanent "low" over the Aleutian Islands. It may be supposed that in the year in which the activity of the Aleutian "low" is increased the inflow of cold air toward the Bering Sea and its neighborhoods becomes vigorous and, therefore, there the winter temperature becomes abnormally low. Again, we may suppose that in the year in which the activity of the Aleutian "low" is decreased, the winter of the northern waters is rather mild.

In the absence of observational data as to variations in the intensity of the Aleutian LOW from year to year, Dr. Okada again resorted to the best substitute available. The activity of the LOW is increased when the water is warmer, or the land is colder, than usual, and consequently he took the air temperature records at Dutch Harbor, Aleutian Islands, as an indication of pressure intensity and corresponding temperature conditions over the more northern waters. As Dutch Harbor is located on the warm side of the Aleutian LOW, it is readily conceivable that its pronounced activity would tend to comparatively high temperature there, with abnormally low temperature over the more northern waters in the cold quadrant of the depression. He correlated the Dutch Harbor temperature with the yield of the rice crop in Hokkaido in northern Japan for the 28-year period mentioned. This gave the significant coefficient of -0.63 ± 0.08. Thus we see that Dr. Okada's investigations point very strongly to an affirmative answer to the question at the head of this review.

[4] Vol. 1, No. 1.

NOTES ON TYPHOONS, WITH CHARTS OF NORMAL AND ABERRANT TRACKS.

By STEPHEN S. VISHER.

[Indiana University, Bloomington, Ind., Oct. 5, 1922.]

INTRODUCTION.

The writer is making a study of the tropical cyclones of the Pacific.[1] Data as to the occurrence of storms in the western portion of the South Pacific and in the southeastern portion of the North Pacific have already been presented in this journal.[2]

In respect to the tropical cyclones in the Far East, there called typhoons, much has been published by others. It was the writer's good fortune to have conferences about typhoons with Director J. Algué, of the Philippine Weather Bureau, with Director T. F. Claxton, of the Royal Observatory at Hongkong, with Director L. Froc, of the Zikawei Observatory, Shanghai, and with Director T. Okada, of the Imperial Marine Observatory, Kobe, Japan. From each of these special students of typhoons copies of publications and maps were obtained, as well as opinions in regard to numerous problems. Although each has studied typhoons for many years, most of their work consists of the plotting of pressure data and the frequent determination of the movement and the changes in the cyclones, with forecasts of future changes, together with the almost hourly issuance of warnings in case a typhoon is threatening. Indeed, each declared that he has almost no time and energy for a quiet study of these complex phenomena and endeavored to encourage the present writer to study typhoons as well as the tropical cyclones of other parts of the Pacific. These kindnesses and encouragements have induced the writer to call attention to the several publications concerning typhoons which have been prepared, often under great difficulties, within the Far East, to make more available some of the data they present and to attempt to contribute a little toward solving some of the problems presented by typhoons.

Annual frequency.—As to the annual frequency of typhoons there is considerable difference of opinion, for a storm which one person considers a true typhoon another may consider not severe enough to be so classed. Then, too, although each observatory attempts to cover the entire region, there is, in fact, a certain amount of specialization. This is frankly recognized by Coronas, who in his Climate and Weather of the Philippines, 1903–1918,[3] attempts to list only the typhoons which noticeably affected the weather of the Philippines. However, several lists of typhoons purport to be complete for the entire Far East. The variation in the annual number of typhoons reported by different authorities for certain years is shown in Table 1.

[1] The field investigations were financed by Yale and Indiana Universities and by the Bishop Museum of Honolulu.

[2] Tropical Cyclones in Australia and the South Pacific and Indian Oceans, Mo. WEATHER REV., 1922, 50: 288–295; and Tropical Cyclones in the Northeast Pacific between Hawaii and Mexico, ibid, 295–297, 1922.

[3] Government printer, Manila, 1920.

TABLE 1.—*Illustrating a lack of agreement as to number of typhoons.*

Year	Algué.	Froc.	Hongkong Observatory.	D. S. H.[1]
1884	21	.....	19	19
1885	11	.....	10	10
1886	16	.....	14	12
1887	28	.....	26	24
1888	16	.....	14	6
1889	14	.....	12	7
1890	27	.....	16	4
1891	28	.....	16	6
1892	24	.....	19	.....
1893	24	11	16	.....
1894	34	31	16	.....
1895	24	19	12	.....
1896	20	13	20	.....
1897	20	14	11	.....
1898	25	22	21	.....
1899	21	22	19	.....
1900	23	23	13	.....
1901	27	21	9	.....

[1] J. Algué, Cyclones of the Far East, p. 86, Manila, 1904; L. Froc, L, Atmosphere en Extreme Orient, pp. 202-239, Paris, 1920; Kongkong Observatory, A list supplied by Director Claxton of the Royal Observatory; D. S. H., Deutsche Seewarte, Segel-Handbuch für den Stillen Ozean, p. 256, Hamburg, 1897.

In recent years, in spite of the wireless, differences of opinion as to whether or not a storm should be classed as a typhoon have not ceased to exist. For example, in 1918, while Claxton reported 18 typhoons, Froc reported 16 and Okada (then at the Central Meteorological Observatory, Tokio) reported 14 severe typhoons and 9 other tropical cyclones. Table 1 reveals the fact that some supposedly complete lists contain only a third, or occasionally a fourth, as many storms for some years as some other authoritative list. Hence any list may be criticized as either being incomplete or as including storms which should not be called typhoons. However, the desirability of having as complete a list as possible, particularly for the study of climatic cycles, is sufficiently great to justify Table 2. This is made up from three sources. For the years 1893 to 1918, inclusive, the list has been compiled from Froc's itemized list of 617 typhoons.[4] These are the storms which are charted in Froc's Atlas of the tracks of 620 typhoons, 1893–1918.[5] Froc's is the longest full list available compiled by a single observer. For the years 1880–1892, Algué's list is reprinted.[6] Although Father Algué is still director of the Philippine Weather Bureau, he informed me that no comprehensive list has been compiled there since 1904. For the years 1919 and 1920 the list supplied me by Director Claxton of the Royal Observatory, Hongkong, was used, as Father Froc has not yet compiled his lists for those years. A very incomplete list for the century before 1880 is given in the Segelhandbuch. However, because of the incompleteness of the list, no very safe deductions as to cycles in their occurrence can be based on these records.

From the foregoing list it appears that, on the average, about 23 severe tropical cyclones occur annually in the Far East. Froc's list for 1893–1918 averages 26 a year. The annual variation is great however—from 11 to 38 according to these data. In a smaller region it is still greater, of course. For example, in the Phillipines the number of especially severe ("remarkable") typhoons varied in the years 1903–1818 from one in 1916 to seven in 1911. Of the two dozen or so typhoons occurring in the Far East in an average year, perhaps half have winds of hurricane force over a wide and long belt. The others possesses winds of hurricane force in only a small area, or perhaps only gales.

Seasonal occurrence.—The months of occurrence of these 917 typhoons are indicated in Table 2. At the bottom of that table is a summary giving the number each month and the per cent of the total. The monthly distribution is shown graphically in Figure 1.

TABLE 2.—*Typhoons of the Far East, by years and months.*

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1880	0	0	0	0	0	0	2	4	2	2	1	0	11
1881	0	0	0	0	2	1	3	4	4	3	3	1	21
1882	0	0	0	1	0	0	3	.....	2	2	1	2	11
1883	0	0	1	1	3	1	3	4	4	4	1	0	22
1884	1	0	0	0	2	1	4	5	4	.....	2	2	21
1885	0	0	0	1	0	2	2	2	1	1	1	1	11
1886	0	0	0	1	1	2	.....	3	4	3	1	1	16
1887	0	0	1	3	3	1	5	2	7	3	3	0	28
1888	0	0	0	1	0	2	4	3	3	1	1	1	16
1889	0	0	0	0	0	0	2	3	2	4	1	2	14
1890	1	0	0	0	1	5	4	2	7	6	1	0	27
1891	0	0	0	1	2	2	7	5	6	0	4	1	28
1892	1	0	0	0	0	3	4	4	5	2	3	2	24
1893	0	0	0	0	1	0	3	2	2	3	0	0	11
1894	0	0	0	1	4	3	7	2	4	4	4	2	31
1895	0	0	0	0	1	4	4	3	4	3	0	0	19
1896	0	0	0	0	1	2	4	2	1	3	0	0	13
1897	0	0	1	0	0	0	4	1	3	4	1	0	14
1898	0	0	1	1	0	0	3	4	4	4	4	1	22
1899	1	2	0	0	2	1	2	4	4	3	3	0	22
1900	2	0	1	0	0	1	1	4	4	4	4	2	23
1901	2	1	0	1	2	2	1	3	2	5	1	1	21
1902	1	0	0	0	3	3	4	2	5	3	1	2	24
1903	3	1	1	1	1	1	3	4	6	6	2	2	31
1904	0	0	2	1	0	2	5	4	3	2	1	3	23
1905	1	0	2	1	1	2	3	4	3	4	1	2	24
1906	1	4	1	0	3	0	2	1	8	3	1	0	24
1907	3	3	1	1	1	2	3	6	4	4	4	0	32
1908	1	1	2	2	3	1	3	4	4	4	3	3	31
1909	5	0	1	1	2	1	4	3	6	6	2	4	35
1910	2	1	2	1	4	2	3	5	10	2	3	3	38
1911	1	2	0	1	1	2	7	6	3	4	2	1	30
1912	4	1	0	0	0	0	3	5	4	4	4	2	27
1913	1	0	0	0	1	0	5	4	5	5	1	1	23
1914	0	0	1	0	1	3	4	6	4	2	2	2	25
1915	0	0	1	0	0	0	3	3	3	7	4	2	23
1916	3	1	0	1	1	1	2	3	6	1	3	1	23
1917	0	0	1	0	0	0	3	5	4	2	1	0	16
1918	0	0	0	1	0	1	4	4	3	3	0	0	16
1919	2	0	1	0	0	1	5	6	4	4	2	1	26
1920	1	0	0	1	0	1	3	6	4	2	2	0	20
Total	37	17	21	24	47	56	141	147	168	132	79	48	917
Per cent in each month	4.0	1.9	2.3	2.6	5.1	6.1	15.4	16.0	18.3	14.4	8.6	5.2	99.9

From Table 2 and Figure 1 it is seen that, although occurring in considerable numbers in every month of the year, tropical cyclones are most frequent in this area

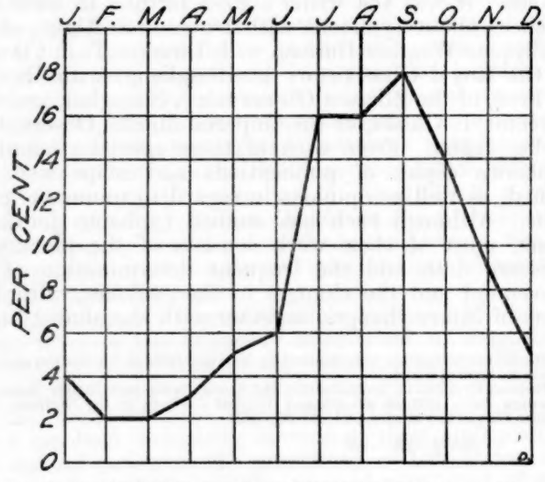


FIG. 1.—Monthly distribution of 917 typhoons in the Far East, 1880–1920.

in the four months July to October. The frequency of storms in July and August has usually been explained by the statement that in those months the doldrums

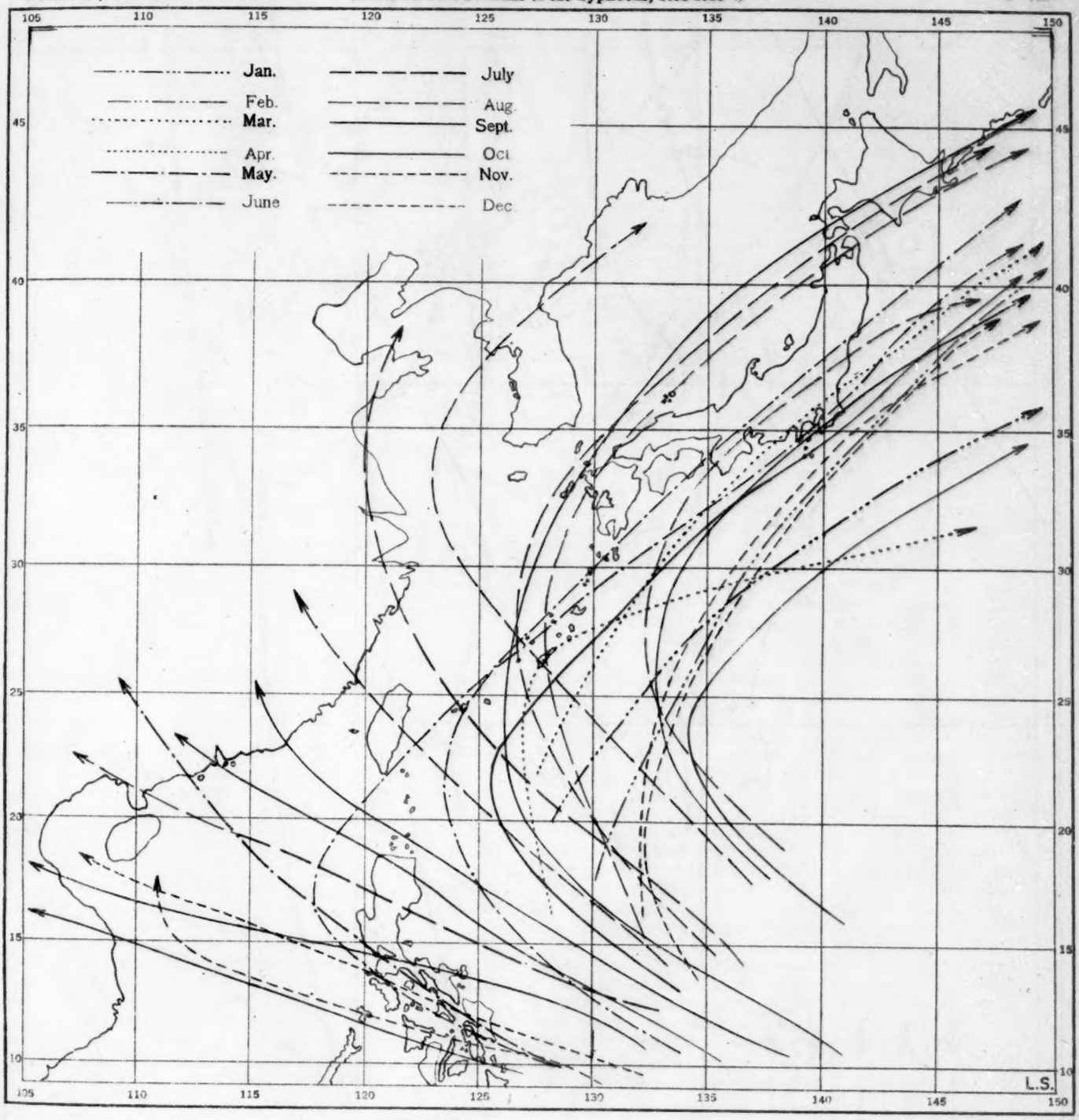
[4] L. Froc: "L'Atmosphere en Extreme-Orient," Deuxiune ed., pp. 202-239, Imprimerie Nationale, Paris, 1920.

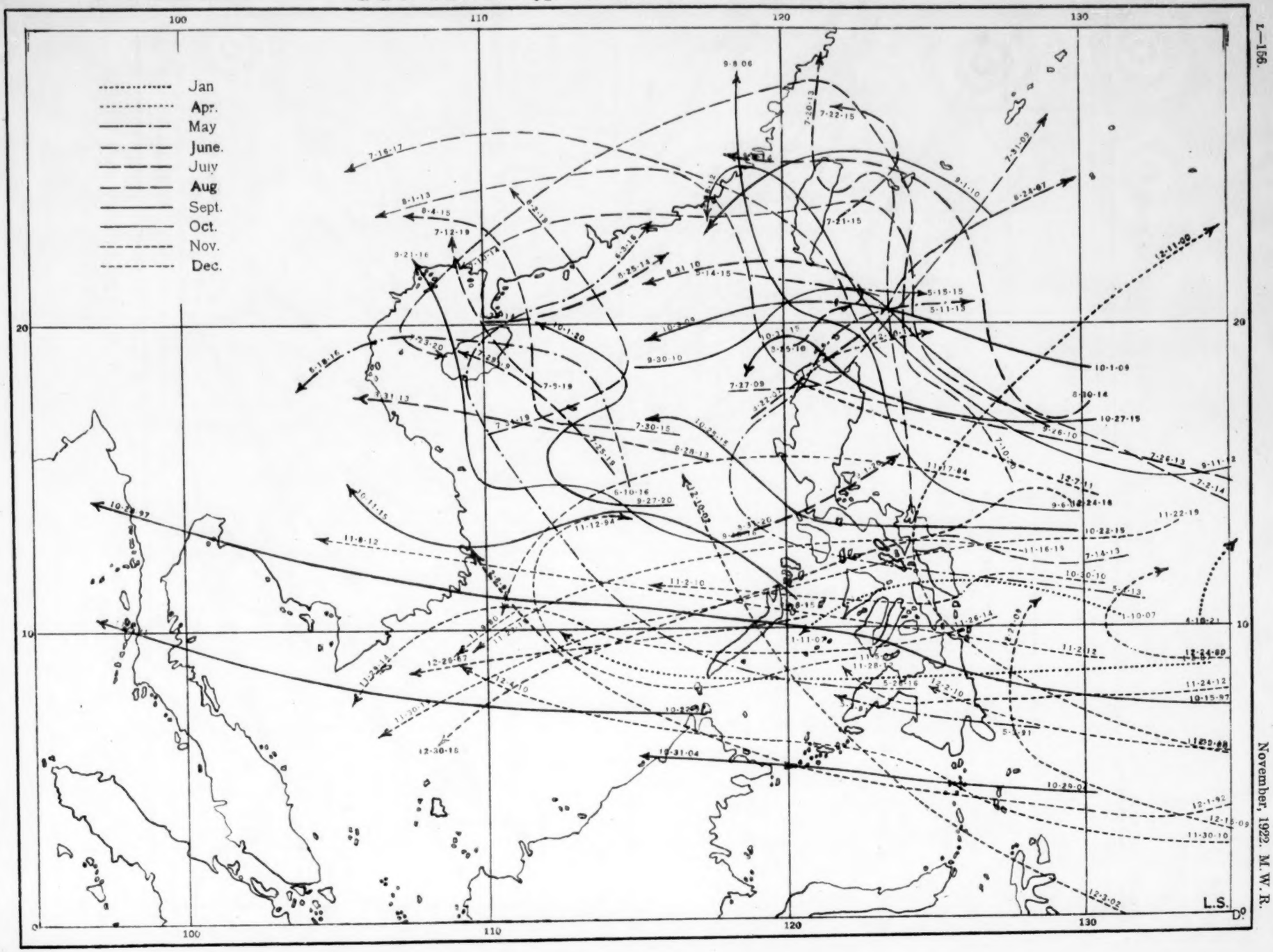
[5] Published in English, by the Zikawei Observatory, Shanghai, 1920. The 21 annotated charts were reprinted in the MO. WEATHER REV., August, 1920, to June, 1921 (vol. 48, Charts 128, 129, 143, 144, 174, 175; vol. 49, Charts, 14-16, 34-36, 50-52, 66-68, 81-83, 95).

[6] J. Algué: "The Cyclones of the Far East," 2d revised edition, p. 86, Manila, 1904.

S. S. V. **Chart I. Typhoons of an average year, month by month.**

November, 1922. M.W.R. (Based on Froc's "Atlas of 620 Typhoons, 1893-1918".) L—155




Jan
Apr.
May
June.
July
Aug
Sept.
Oct.
Nov.
Dec.
100
110
120
130
20
10
0
L.S.

are farthest from the Equator. However, this explanation is inadequate, for by October, or at least by November, the doldrums are far south of their June position, a month of relatively few typhoons. Furthermore, typhoons are rarest in February and March, not in January, the coolest month.

The monthly distribution of cyclones in the Philippines is given in Table 3.[7]

TABLE 3.—*Average monthly distribution of tropical cyclones in the Philippines, 1903–1918.*

[Per cent.]

	January.	February.	March.	April.	May.	June.	July.	August	September.	October.	November.	December.	Storms per year.
Remarkable typhoons	1.7	0	0	1.7	5.0	6.7	10.0	15.0	21.7	21.7	10.0	6.7	4
Ordinary typhoons	4.9	0	4.9	4.9	9.8	3.3	9.8	3.3	13.1	13.1	24.6	8.2	5
Average	3.3	0	2.4	3.3	7.4	5.0	9.9	9.2	17.4	17.4	17.4	8.0	....

The monthly distribution of the storms of yet another special portion of the Far East merits particular attention. In a later table (7) 70 typhoons occurring in latitudes 3°–8° are listed. Tropical cyclones are relatively rare so near the Equator. Hence it is worth while to call especial attention to their frequency in the region under consideration. Table 4, based on Table 7, gives the number and the per cent in each month.

TABLE 4.—*The monthly distribution of 70 typhoons occurring in latitudes 3°–8°.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Number.	4	2	4	1	6	6	5	4	4	9	9	16
Per cent.	5.7	2.9	5.7	1.4	8.6	8.6	7.1	5.7	5.7	12.9	12.9	22.8

The monthly distribution of these subequatorial typhoons may be contrasted with that of typhoons in general (fig. 1). Near the Equator typhoons are most frequent later in the year than farther north, in December rather than September. Likewise they are rarest, according to these data, in April rather than in February and March. On the other hand, May and June have more typhoons near the Equator than August and September, while the reverse is strikingly true in latitudes above 8°. These latitudinal contrasts in the monthly distribution are probably due to variations in the extent and effect of the Asiatic high-pressure area rather than to the shifting of the doldrums, the common explanation. Indeed the heat equator is in the Southern Hemisphere during nearly half the year.[8]

Tracks followed.—Froc's "Atlas of the tracks of 620 typhoons" has already been mentioned. It is an extremely valuable atlas, but it seems desirable for several reasons to present a chart of average tracks based on the 21 charts he gives. So many charts, each covered with a maze of tracks, are bewildering, as he himself remarks. Furthermore, in textbooks in meteorology, geography, and physiography only a single chart can normally be used. The chief reason why Doberck's original chart is reproduced in recently published textbooks, in spite of its having been based on the very inadequate data available 40 years ago, appears to be the lack of a more satisfactory single chart. Chart I was obtained by drawing one average track for each 25 tracks given by Froc, this being done month by month. The 26 tracks thus obtained represent the average number of typhoons occurring annually in the years 1893–1918, according to Froc. The monthly distribution of the 26 typhoons occurring in an average year is indicated by the different symbols used for the storms of each month. This Chart I is both simple and fairly accurate. The greatest inaccuracy arises from the necessity of omitting the storms which follow very aberrant courses. Such storms are too few and too individualistic to be properly represented on such a chart of the tracks for a normal year. Hence Chart II, showing aberrant tracks alone, has been prepared and will be considered later.

From Chart I it is evident that on the average the storms are first recorded somewhere east of the Philippines. About a third cross the Philippines, while another third rather promptly move northward and northeastward, passing not far east of Japan. The remaining third move westward to the north of the Philippines and then turn northward across the east China Sea and Sea of Japan or across Japan itself. Among the storms which cross the Philippines many continue west-nortwestward onto the Asiatic coast, while a few recurve in the south China Sea and move north-northeast toward Japan.

The courses followed on the average by storms differ notably, however, with the seasons, as may be seen from Chart I. From January to April the storms usually move northward east of the Philippines, Formosa, and Japan, although the easternmost tip of Japan is normally crossed by a March storm. During May and June two storms cross the Philippines, one continuing to South China while the other recurves and crosses Japan from south to north. A third storm recurves promptly and strikes only the eastern tip of Japan. In July and August one storm crosses Luzon, another crosses Formosa, two others reach the Yellow Sea, while the remaining two pass along the western side of Japan. In September and October there are on the average eight storms, following diverse tracks and penetrating all large parts of the region except northern China. In November and December two storms cross the southern Philippines and two move off northeast well to the east of Japan.

This seasonal change in the course of typhoons is strikingly illustrated in another way by 12 small "Summary maps" in Froc's Atlas. These maps indicate that no typhoons normally reach the Asiatic coast in January, February, or March, while in April and December the only part crossed or closely approached by typhoons is far south, in Siam. In May and November the coastal area of danger has expanded northward to latitude 20°. On the other hand, from July 1 to October no part of the Asiatic coast is free from danger from typhoons except the extreme south. In October the coast north of 30° is again free from grave danger, while Siam is again threatened. As to the Philippines: Luzon is very seldom approached by typhoons in January, February, or March, while the danger is considerable in the southern islands during every month except August.

ABNORMAL TRACKS.

While most typhoons are fairly normal, there are on the average two or three a year which follow aberrant tracks along part of their tropical courses. Hence it is quite essential for navigators to understand that wide

[7] J. Coronas: The Climate and Weather of the Philippines, 1903–1918, pp. 181, 185, 1920.
[8] Griffith, Taylor: Australian meteorology, London, 1920.

departures from the normal should be expected. In order that the character of the departures may be readily apparent, Chart II has been compiled from many sources.[9]

The monthly distribution of the 57 aberrant storms plotted on Chart II is shown in Table 5.

TABLE 5.—*Monthly distribution of 57 typhoons which followed unusual paths along part of their tropical course.*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Monthly number	2	0	0	1	4	1	11	6	5	7	11	8
Per cent (approximate.)	4	0	0	2	7	2	20	11	9	12	20	14

When this distribution is compared with that of typhoons in general, Table 2 and fig. 1, it becomes evident that abnormal typhoons have a less symmetrical monthly distribution than normal typhoons and that, although they are rare or lacking in February, March, and April when normal typhoons are rarest, they are not most abundant when typhoons are most frequent. Only 20 per cent of the abnormal storms occurred in August and September in contrast to 34 per cent of the normal storms. On the other hand, while only 14 per cent of all typhoons occur in November and December, 34 per cent of the aberrant storms occur in those two months. Many of the aberrant storms of November and December, however, are remarkable rather for the low latitude of their occurrence than for their abnormal direction of progression. It will be recalled that nearly 36 per cent of the typhoons occurring within 8° of the Equator develop in November and December. (See Table 4.) Additional facts concerning these aberrant storms are presented in Table 6.

TABLE 6.—*Abnormal movements of aberrant typhoons classified by months, etc.*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Typhoons which moved easterly below lat. 20° (some without first recurving)	0	0	0	1	1	0	2	2	1	0	1	3	11
Typhoons which moved south of due east in latitudes below 15°	1	0	0	0	0	0	0	0	0	1	5	2	9
Typhoons which moved south of due east in latitudes north of latitude 15°	0	0	0	0	0	1	2	2	3	2	0	0	10
Typhoon tracks forming south curves or loops in low latitudes	0	0	0	0	0	0	5	2	4	3	2	0	16

From Table 6 it appears that there is slight likelihood that a typhoon occurring in February to May will move in a southerly direction. Indeed, south of latitude 15°, the chance of this particular abnormality remains almost negligible until October, but is considerable in November. The likelihood of a typhoon moving in an easterly direction in latitudes below 20° rather than in a westerly or northerly one appears to be greatest in December, July and August. The prospect of a sinuous course, perhaps with a loop, seems appreciable only in July to November, but in those months so many typhoons depart from a straight course or a simple parabolic curve that the possibilities of abnormal change of direction are considerable north of latitude 15°.

The abnormal typhoons dealt with in Chart II are of great scientific interest, too, for in respect to many natural phenomena, as well as in psychology and medicine, the abnormal may reveal more than do the normal in regard to fundamental causes and relations. The irregular movements of these typhoons emphasize the importance of irregular changes in atmospheric pressure. The importance of such changes have been recognized by a few meteorologists, but most students of storm movements have relied on the influence of regular rather than irregular forces to explain their movements. For example, relief features, the prevailing wind directions, and Ferrel's law of deflection to the right in the Northern Hemisphere have been called upon to explain the recurve of tropical cyclones. All three of these forces combined appear totally inadequate to explain many of the curves seen on Chart II. Many storm tracks fail to show any response to Ferrel's Law, while many appear to ignore the prevailing winds. Comparison of the winds in January and February and July and August, as shown by Köppen,[10] with the tracks of typhoons, reveals the fact that many typhoons advance toward the prevailing wind. Likewise, topographic features can not explain most of the curves, since a large majority of them take place far from land. The location of the recurve has been casually related by some authorities to the position of the permanent oceanic high-pressure area.[11] Nevertheless it is obvious from Chart II that, however much the average position of the recurve may be affected, many exceptions occur.

The irregularities in pressure conditions, believed responsible for the irregular course of many typhoons, are often difficult to explain, but that does not make them the less potent.

Typhoons within 8° of the Equator.—It has usually been considered that the small deflective effect of the earth's rotation near the Equator will prevent the development of cyclonic storms there. Instead of circling round and round, the air tends to flow directly in toward a depression and fill it up. This is so plausible that the occasional typhoon near the Equator has often been ignored. Indeed some writers on tropical cyclones state or imply that hurricanes can not occur within 8° of the Equator.[12] Hence it appears worth while to print Table 7. It will be noted that during the five years 1908–1912, 32 typhoons are recorded as having their center in or below latitude 8°. The annual range in those years was from four in 1908 to nine in 1910. Published information for the years of the World War is less complete than for the years 1908–1912, but I was informed by Director Okada, of the Japanese Imperial Marine Observatory, that the meteorological conditions at Jaluit in the Marshall Islands, where a reporting station was established as soon as the islands were captured by the Japanese, frequently indicate typhoons west and southwest of Jaluit (latitude 6° 8′, longitude 170° E.)

[9] Algue, loc. cit., Director Claxton and Doberck (before 1902) Maps of typhoons year by year in annual reports of Royal Obs., Hongkong; Froc, L. Atmosphere en Extreme-Orient, Carte 16-36, 1920; Coronas, Climate, and Weather of the Philippines, loc. cit.; T. Okada, Weekly Weather Report (daily weather maps and a summary of storm movement), Imperial Marine Obs., Kobe, Japan, 1920, 1921; H. Kondo, The Climate, Typhoons, and Earthquakes of Formosa, Meteorol. Obs. Taihoku, 1914; Deutsche Seewarte, Segelhandbuch fur den Stillen Ozean, 1897; W. E. Hurd: Cyclonic Storms and Typhoons of the North Pacific, article on the reverse of Meteorological Charts of the North Pacific, U. S. Weather Bureau, January, March, and April, 1913; and Monthly Pilot Charts of the North Pacific, U. S. Hydrographic Office, 1921.

[10] Reprinted in W. J. Humphreys's Physics of the Air, 1920, in Willis L. Moore's Descriptive meteorology, 1910, and in many other places.

[11] Vines, quoted by O. L. Fassig, Hurricanes of the West Indies, Bull. X, U. S. Weather Bureau, 1913.

[12] W. I. Milham; Meteorology, p. 274, 1912.

TABLE 7.—*Typhoons whose centers were from 3°–8° from the Equator, by months.*[1]

	Lat.	Long.		Lat.	Long.
	°	°		°	°
Jan. 8, 1907	8	136	Oct. 2, 1880	5	122
1, 1916	7	150	22, 1891[2]	7	118
13, 1916	8	128	13, 1897	7	140
22, 1916	7	128	16, 1897[3]	7	140
Feb. 13, 1911	8	136	29, 1904	5	130
25, 1911	6	142	26, 1909	8	138
Mar. 6, 1898	8	130	26, 1910	8	142
18, 1909	8	138	10, 1911	7	142
13, 1910	8	138	25, 1915	7	150
Apr. 8, 1918	6	143	Nov. 8, 1892	6	125
May 3, 1891	5	132	9, 1897	8	145
6, 1896	7	135	12, 1909	8	138
23, 1908	8	127	6, 1910	8	138
1, 1910	7	139	3, 1912	7	140
3, 1910	8	137	18, 1912	7	143
26, 1916	7	124	22, 1912	7	143
June 11, 1894	6	132	26, 1912	7	140
4, 1895	7	137	1, 1920	7	141
2, 1896	7	137	Dec. 1, 1892	5	125
30, 1905	6	169	12, 1900	4	139
10, 1914	8	133	18, 1905	7	150
24, 1914	8	140	2, 1908	7	143
23, 1918	8	144	3, 1908	7	134
July 5, 1881	8	124	3, 1909	7	134
12, 1895	7	145	15, 1909	5	143
22, 1895	7	138	15, 1909	3	146
30, 1896	8	136	1, 1910	4	140
12, 1913	8	133	1, 1910	7	137
Aug. 12, 1880	7	120	19, 1910	8	138
19, 1892	5	133	2, 1911	8	145
19, 1909	8	143	3, 1911	6	143
19, 1913	8	145	1, 1912	7	141
Sept. 24, 1897	8	133	2, 1912	8	145
10, 1901	8	133	20, 1918	6	146
19, 1908	7	137	30, 1918[4]	7	105
6, 1910	8	116			

[1] From charts or lists by Algué, Coronas, Froc, Claxton, U. S. Hydrographic Office and D. Segelhandbuch, all cited in full in previous foot notes.
[2] To Calcutta, crossed latitude 10° in longitude 97° E.
[3] To Bay of Bengal, crossed latitude 10° in longitude 122° E.
[4] End of previous storm.

Relative to the severity of some subequatorial typhoons the following quotations from Hurd are pertinent.[13] "It sometimes happens that typhoon-like storms lasting for three or four days break upon the Gilbert Islands, near the Equator (lat. 4° N. to 3° S.) and 174° E. The strong shifting winds, though of rare occurrence, inspire the natives with such fear that they prop their huts with stakes and tie them down to prevent them from blowing away. A brief account comes to us of a typhoon which visited Strong Island in latitude 5° 12′ N., longitude 163° E., during the early part of the nineteenth century and inflicted such destruction upon the breadfruit trees, the chief source of sustenance to the islanders, that a famine ensued which carried off nearly all the inhabitants. The island of Ponape, about 300 miles to the northwestward, in the Carolines, was at the same time similarly visited."

A hurricane did great damage in the southern Marshall Islands (latitude 6) on June 30, 1905. The barometer at Jaluit fell to 936 mb. (27.6 inches), while the tidal wave rose to a height of 46 feet at Mille.[14]

Concerning a typhoon which crossed northern Borneo (latitude 6°) on October 31, 1904, Algué reports as follows:[15] "This was a very destructive typhoon * * * very well developed and of great intensity * * * we think the minimum must have been below 742 mm. * * * The waves dislodged great rocks, some of them more than 3 cubic meters in size. * * * The storm destroyed a great part of the fruit trees and * * * wrought havoc among trees of every kind. * * * Numerous buildings were laid in ruins." The track of this storm is shown on Chart II. A typhoon which crossed the southern large island of the Philippines on November 28, 1912, is described by Algué and others as having been of terrible intensity and destructiveness, as well as being remarkable in having progressed due west at the rate of 21 miles an hour from south of Yap (longitude 138°) to longitude 127°, where it struck Mindanao in latitude 7°.[16]

Destructive tropical cyclones within 7° of the Equator are not limited to the Far East. For example, Ellice Island (latitude 5½° S., longitude 176° E.) experienced what the Admiralty Sailing Directions (British) characterized as "a very severe hurricane" on February, 1891. The American Pacific Island Pilot states that this hurricane almost devastated the islands. This storm later caused great destruction in Tonga, and was traced for over 1,500 miles. Five hurricanes have been recorded within 6° or 7° from the Equator near Timor, (longitude 125° E.).[17]

Longitude of origin.—Doberck, 30 years ago, thought that many typhoons originated in the China Sea. However, soon after the Philippine Meteorological Service was organized it was discovered that nearly all China Sea typhoons actually originated to the east of the Philippines. Algué pointed this out in 1904. With the establishment of reporting stations at Guam and Yap, the place of origin of many storms was found to lie much farther east than had been suspected, being to the east of these islands. To-day, although it is established that most typhoons first attain destructive violence west of longitude 150°, the recently established Japanese Meteorological Observatory on Jaluit, longitude 170°, latitude 6°, frequently reports to Doctor Okada that cyclonic disturbances pass on their way westward. Such observations make more plausible the suggestion of Kimball that some of the tropical cyclones which develop off the west coast of Mexico and Central America may cross the Pacific.[18] (It will be recalled that two hurricanes have been traced westward most of the distance across the Atlantic, from off the west coast of Africa to the West Indies.)

When questioned as to how far east typhoons sometimes originate, Algué, Froc, and Okada all expressed the belief that occasionally one develops far out in the Pacific.

Of the storms which originate fairly near reporting stations, there is considerable seasonal variation in latitude and longitude of place of origin. The latitudinal changes have been touched on already. In brief, the winter storms originate either farther south or farther north than the storms of the main typhoon season. On the other hand, in respect to longitude, Chart 1 and other data suggest that the winter and spring storms normally originate somewhat west of the average longitude of summer and autumn storms. However, Froc believes that the longitude of origin is progressively farther eastward month by month from October to January.[19]

Distances typhoons travel.—Although a good many typhoons "fill up" and disappear before having been traced more than a thousand miles, many more continue as lesser disturbances for much longer distances—several thousand miles. Some have been known to retain much of their original strength over a course of many thousands of miles, from east of the Philippines, north past Japan, and eastward across most of the North Pacific to off the British Columbia coast. A great many more weaken after having been typhoons for two or three thousand miles, become converted into extratropical cyclones, and proceed long distances, perhaps across North America and the Atlantic Ocean. In the other direction, two typhoons have been traced

[13] Willis E. Hurd: Cyclonic storms and typhoons of the North Pacific, loc. cit., on reverse of meteorological chart of the North Pacific, U. S. Weather Bureau, March, 1913.
[14] Pacific Islands Pilot, second edition, U. S. Hydrographic Office, vol. I, p. 541, 1920.
[15] J. Algué Monthly Bulletin of the Philippine Weather Bureau, Nov., 1904, quoted by Coronas, loc. cit., p. 169.
[16] J. Algué: Bulletin for November, 1912, Weather Bureau, Manila, pp. 402–405, 1913.
[17] See appendix on hurricanes of Timor in S. S. Visher, Tropical cyclones of Australia, Commonwealth Bureau of Meteorology, Melbourne, Australia, 1922.
[18] J. H. Kimball, MO. WEATHER REV., 1915, 43; 486.
[19] Froc, Atlas, loc. cit., Chart 21, etc.

from east of the Philippines to the head of the Bay of Bengal, a distance of 4,500 miles in the case of one of the storms.[20]

The tendency for cyclonic storms to weaken markedly in areas of high pressure often causes them to be lost sight of before they have really disappeared. Both Froc and Okada told me of having traced typhoons far into Asia, and, after all ordinary signs of them had vanished except a slightly lower pressure, had seen them greatly intensify upon reaching the sea again. Both these authorities expressed the opinion that when sufficient pressure data are available a close study will prove that most typhoons give rise to what are generally known as extratropical cyclones.

Size of typhoons.—Although on the average a belt 300 or 400 miles wide experiences gales when a typhoon passes, sometimes the area is much smaller or vastly larger. Froc mentions two extreme cases. One destructive typhoon had no obvious influence on wind or pressure at a meteorological observatory only 75 miles from the center of its track, while another typhoon produced gales throughout a belt 1,800 miles across. Normally the size of the area affected increases as the typhoon progresses, especially where it reaches middle latitudes. The region of especial destructiveness is the strip usually from 10 to 30 miles wide over which the eye of the storm passes. Indeed it often happens that only in this narrow belt is much damage done by winds or waves, although torrential rains may cause a wider damage.

Rate of progression of typhoons.—Typhoons vary greatly in respect to speed of travel. Some remain almost stationary for a day or two, while others have been known to travel at the rate of 50 miles per hour, or 1,200 miles per day, past Southern Japan. The mean speed also varies in respect to the season, and especially with the particular portion of the course. In general it is greatest during the main typhoon season, and much faster when the storm is going northeastward, after recurring, than in lower latitudes. It will be noted, however, that the lowest mean speed for the storms of any month is 6 miles per hour, or 150 miles per day, while the fastest mean speed is 25 miles an hour, or 600 miles per day. Table 8 is from Tables 1 and 2 of Froc's Atlas.

TABLE 8.—*Mean and extreme speed of typhoons along their tracks in miles per hour, by months and regions.*[1]

[From Froc.]

Month.		China Sea north to latitude 18°.		North China Sea, latitude 18°–23°.		Formosa to latitude 30°.		Yellow Sea.		Near Japan.		Open Pacific.	
		NW.	NE.	NW.	NE.	NW.	NE.	NW.	NE.	NW.	NE.	NW.	NE.
Jan.	Mean	11.0	...	...	...	...	...	...	...	...	23.4	...	18.8
	Extreme	14	...	...	...	...	...	...	...	...	30	...	31
Feb.	Mean	9.0	...	...	...	...	...	...	...	13.3	16.0	...	21.6
	Extreme	9	...	...	...	...	...	...	...	18	18	...	40
Mar.	Mean	6.0	...	...	...	...	...	...	...	10.0	21.5	11.0	21.6
	Extreme	6	...	...	...	...	...	...	...	...	30	11	30
Apr.	Mean	9.7	...	...	...	...	...	...	...	7.5	20.7	13.7	26.0
	Extreme	12	...	...	...	...	...	...	...	8	28	10	43
May.	Mean	11.3	...	10.0	...	...	...	...	...	9.7	19.2	8.9	16.9
	Extreme	16	...	10	...	...	...	...	...	13	25	16	28
June.	Mean	10.1	...	10.0	...	11.5	18.7	...	...	...	14.0	9.0	17.1
	Extreme	15	...	12	...	16	23	...	...	...	14	10	32
July.	Mean	10.8	...	8.7	25.0	10.3	19.8	11.4	18.6	11.9	18.9	11.3	18.5
	Extreme	14	...	13	...	12	23	15	26	16	25	15	28
Aug.	Mean	10.7	...	10.2	12.0	11.1	20.2	12.9	18.7	11.1	18.9	13.2	18.0
	Extreme	14	...	16	12	22	26	20	27	21	40	17	25
Sept.	Mean	11.0	...	10.8	[40.0]	12.1	22.4	10.6	21.4	11.9	22.8	10.0	18.2
	Extreme	17	...	18	...	17	34	16	25	20	52	15	38
Oct.	Mean	10.6	...	9.9	10.0	13.5	...	...	21.0	11.9	21.5	12.5	17.0
	Extreme	16	...	12	10	15	...	...	21	20	39	20	25
Nov.	Mean	10.1	...	8.0	8.0	...	...	...	...	16.3	22.6	8.2	16.8
	Extreme	16	...	8	8	...	...	...	...	15	40	11	25
Dec.	Mean	11.8	...	12.0	...	...	...	...	...	11.0	25.0	12.0	19.7
	Extreme	16	...	12	...	...	...	...	...	12	38	12	28
	Mean	10.2	...	10.1	19.0	11.7	20.3	11.6	19.9	11.5	20.4	11.0	19.2

[1] NW.=typhoons moving northwest.
NE.=typhoons moving northeast.
Leader (...)=no storms of this type normally occur in this month.

[20] J. Algué: Cyclones of the Far East, loc. cit., pp. 219–229.

Destructiveness of typhoons.—While most typhoons cause little or no loss of human life, occasionally the losses are appalling. The Swatow typhoon of August 3–4, 1922, caused the death of over 50,000 persons.[21] The typhoon which struck Haifong, China, on October 8, 1881, was said to have caused the death of 300,000 persons. The two almost simultaneous typhoons of August 26–31, 1911, destroyed 44,000 houses in the southern part of Formosa, although only about 800 persons were killed or missing.[22] The destruction due to typhoons is of four chief kinds: (1) The wind itself demolishes houses, breaks off trees, and sometimes blows boats upon the rocks. (2) Waves produced by the wind often engulf boats or break them or drive them upon the shore. Such waves also occasionally do great damages upon low lying coasts. (3) The rise in sea level due to the piling up of the water in the center of the storm by the inblowing winds often is very destructive. Indeed the sea level itself is sometimes raised more than 10 feet by this means, and the great waves sometimes reach heights of 30 feet above normal sea level.[23] (4) The torrential rains commonly associated with typhoons frequently cause disastrous floods. Rainfall in excess of 30 inches in three days is not rare in connection with typhoons and occasionally that much falls in 24 hours.[24]

Anomalies in typhoons.—Father Algué presents a chapter on anomalies in cyclones which merits brief comment.[25] He remarks on (1) stationary cyclones, (2) cyclones without rain, (3) notable fall in barometer without corresponding wind, (4) strong wind with a slight fall in barometer, (5) cyclones which deviate much from mean normal trajectory (he also discusses some notable peculiarities, which he calls apparent anomalies), (6) bifurcation of cyclones, and (7) secondary cyclones. His remarks may with profit be briefly summarized with some additional comments. He considers that so-called stationary cyclones may have only a slow movement. Since 1904 additional data gathered in many parts of the world suggest that well-developed tropical cyclones do not actually stand still, although they often progress so slowly that they appear to be stationary. As a special cause of slow progression along the normal trajectory may be mentioned the loops which sometimes occur. In such a case from a moderate distance it might appear that the storm was stationary.

As to typhoons without rain, Algué thinks that such do not exist, although it often happens that at any given point only a little rain may fall when a typhoon passes near by. However, it certainly is true that there is a wide difference in the amount of precipitation occurring in storms of equal intensity. This is often illustrated in Australia.[26]

A notable fall in the barometer without corresponding wind Algué explains as probably due to the rise from off the ground of a part of the typhoon. Because tornadoes often rise off the ground, Algué thinks that typhoons may occasionally do so.

Strong wind with only a slight fall in the barometer occurs fairly frequently. Algué ascribes it to the existence of a secondary cyclonic nucleus, or by rapid condensation giving rise to rain squalls.

[21] Cf. MO. WEATHER REV., August, 1922, pp. 433–437.
[22] H. Kondo: The Climate, Typhoons, and Earthquakes of Formosa (Taiwan), p. 65, 1914.
[23] Waves reached 46 feet above sea evel at the typhoon at Mille, latitude 6°, in the Marshall Islands, June 30, 1905, according to The Pacific Island Pilot, 2d ed., vol. 1, p. 541, 1920.
[24] S. S. Visher, Variability vs. Uniformity in the Tropics, Scientific Monthly, Vol. 1q, p. 31, 1922.
[25] J. Algué: Cyclones of the Far East, pp. 230–236, 1904.
[26] E. T. Quayle: Tropical control of Australian Rainfall, Bull. 15, Commonwealth Bur. of Meteorol., 1920.

Deviation from the normal course Algué explains as usually due to the presence not far away of another typhoon. However, there is record of a hurricane in Fiji which recurved so sharply on its course that its center passed twice over the city of Levuka, and yet no other disturbance was known to be anywhere near. Furthermore, this hurricane traveled northwest from Levuka after its first passage over that city, the opposite direction from that which tropical cyclones normally take in that latitude in the southern hemisphere.[27]

Bifurcation of cyclones.—Sometimes it happens that a well-developed cyclone apparently divides into two independent, comparable storms, each of which henceforth follows an independent course. Algué suggests that topographic barriers may be the cause, but the cases he considers do not make this explanation altogether satisfactory.

Secondary whirls sometimes develop within a cyclone, producing destructive winds far from the center of the main cyclone. Algué has repeatedly observed such secondary centers in the Philippines. Doctor Okada reports that two or three secondary centers sometimes occur within a typhoon.

Typhoons and mountains.—It is stated in some standard meteorologies that tropical cyclones can not cross a mountain range 3,000 feet high. This is often disproven in the Far East, for typhoons sometimes cross mountains of greater height than this in Taiwan (Formosa), in the Philippines, in Japan, and elsewhere. Mountainous Formosa often appears to deflect typhoons which approach it at a small angle, and sometimes cuts the typhoon in two, according to Froc, but, on the other hand, other storms clearly cross it with no apparent regard for its mountains, the highest of which reach over 13,000 feet. Doctor Okada reports that studies made on lofty Fuji, near Yokohama, and on the higher mountains of Formosa indicate the depth of most typhoons to be approximately 5 or 6 kilometers (16,000 to 20,000 feet).

Although it is commonly stated that typhoons weaken decidedly as soon as they come upon the land, both Froc and Okada have observed many cases where this was not true in southeast China, the typhoons maintaining most of their force until encountering lofty mountains.

THE CHANGING ARCTIC.

By GEORGE NICOLAS IFFT.

[Under date of October 10, 1922, the American consul at Bergen, Norway, submitted the following report to the State Department, Washington, D. C.]

The Arctic seems to be warming up. Reports from fishermen, seal hunters, and explorers who sail the seas about Spitzbergen and the eastern Arctic, all point to a radical change in climatic conditions, and hitherto unheard-of high temperatures in that part of the earth's surface.

In August, 1922, the Norwegian Department of Commerce sent an expedition to Spitzbergen and Bear Island under the leadership of Dr. Adolf Hoel, lecturer on geology at the University of Christiania. Its purpose was to survey and chart the lands adjacent to the Norwegian mines on those islands, take soundings of the adjacent waters, and make other oceanographic investigations.

Dr. Hoel, who has just returned, reports the location of hitherto unknown coal deposits on the eastern shores of Advent Bay—deposits of vast extent and superior quality. This is regarded as of first importance, as so far most of the coal mined by the Norwegian companies on those islands has not been of the best quality.

The oceanographic observations have, however, been even more interesting. Ice conditions were exceptional. In fact, so little ice has never before been noted. The expedition all but established a record, sailing as far north as 81° 29′ in ice-free water. This is the farthest north ever reached with modern oceanographic apparatus.

The character of the waters of the great polar basin has heretofore been practically unknown. Dr. Hoel reports that he made a section of the Gulf Stream at 81° north latitude and took soundings to a depth of 3,100 meters. These show the Gulf Stream very warm, and it could be traced as a surface current till beyond the 81st parallel. The warmth of the waters makes it probable that the favorable ice conditions will continue for some time.

Later a section was taken of the Gulf Stream off Bear Island and off the Isfjord, as well as a section of the cold current that comes down along the west coast of Spitzbergen off the south cape.

In connection with Dr. Hoel's report, it is of interest to note the unusually warm summer in Arctic Norway and the observations of Capt. Martin Ingebrigtsen, who has sailed the eastern Arctic for 54 years past. He says that he first noted warmer conditions in 1918, that since that time it has steadily gotten warmer, and that to-day the Arctic of that region is not recognizable as the same region of 1868 to 1917.

Many old landmarks are so changed as to be unrecognizable. Where formerly great masses of ice were found, there are now often moraines, accumulations of earth and stones. At many points where glaciers formerly extended far into the sea they have entirely disappeared.

The change in temperature, says Captain Ingebrigtsen, has also brought about great change in the flora and fauna of the Arctic. This summer he sought for white fish in Spitzbergen waters. Formerly great shoals of them were found there. This year he saw none, although he visited all the old fishing grounds.

There were few seal in Spitzbergen waters this year, the catch being far under the average. This, however, did not surprise the captain. He pointed out that formerly the waters about Spitzbergen held an even summer temperature of about 3° Celsius; this year recorded temperatures up to 15°, and last winter the ocean did not freeze over even on the north coast of Spitzbergen.

With the disappearance of white fish and seal has come other life in these waters. This year herring in great shoals were found along the west coast of Spitzbergen, all the way from the fry to the veritable great herring. Shoals of smelt were also met with.

BIRDS STORM-SWEPT OVER THE NORTH ATLANTIC OCEAN.

By WILLIS E. HURD.

[Weather Bureau, Washington, D. C., Dec. 10, 1922.]

An interesting memorandum was recently received by the Weather Bureau in connection with a marine weather report from Mr. W. Scott, fifth officer of the American S. S. *Manchuria*. It deals with the appearance of several varieties of small land birds a considerable distance at sea on the 27th to 29th of October, 1922, during a voyage from New York to Hamburg, and is presented here, with an inclusion of the list of observed bird varieties, for the scientific interest involved.

S. S. *Manchuria*,
Voyage 50—N. Y.–HAMBURG,
October 28, 1922.

It may be of some interest to the Department of Plants and Animals or to the Smithsonian Institution to note that on October 27, latitude 40° 36′, longitude 66°, to noon 28th, latitude 41° 45′, longitude 59° 27′,

[27] R. L. Holmes: Quart. Journ, Royal Meteorol. Soc., January, 1905.

several hundred birds alighted on the ship, having been blown to sea by a strong northwest breeze, evidently as they were migrating south.

The following varieties were noted:

Robins, 6 or more.
Starlings, several.
Thrushes, several.
Catbird, one seen.
Flicker, or yellow hammer, one seen.
Ground, or vesper, sparrows, many.
Bluebirds, several.
Small birds with mixed greenish feathers, like flycatchers, smaller than sparrows, many.
Small dove-colored birds size of sparrows, many.
Brown sparrows, trifle larger than English sparrows.
Birds size of sparrows with two white feathers in tail, possible snowbirds, many.
Birds a little larger than sparrows with much white on wings and back, a variety which kept well together, not seen around New York City, 12 or more.

At the time these birds began to alight on the ship, there seemed to be many more on the sea, and I have no doubt thousands of birds are lost each year during the migrating season in strong offshore breezes.

The birds are dying rapidly or fail to "make the ship" again, though on Sunday (29th) there were light airs, and many of the smaller birds and several robins are still with us.

Doubtless all will be blown to sea in the first gale and perish.

It is quite possible the ornithological societies may be well aware of loss of birds along the coast, but I have never seen it mentioned, though a "bird lover," in any article on the subject.

Aside from the facts in this communication, a press report contains an account of a similar visitation on board the Cunard liner *Scythia* on her trip from New York to Liverpool, beginning October 26. When about 400 miles from the American coast, an extraordinary gathering of birds, estimated to be many thousands in number, settled on the steamer's deck and rigging. They included many types of small birds, as well as a few owls. Great numbers remained on board throughout the voyage.

During this period a storm of considerable intensity prevailed in the neighborhood, being central over the Canadian maritime provinces. On the afternoon and evening of the 26th moderate to strong northwesterly gales were prevalent from New York City and the vicinity eastward, and on the 27th fresh to whole gales from some westerly direction swept a large sea area south and east of Nova Scotia.

This extratropical cyclone, then, may be assigned as having caused the presence of so great a number and variety of birds in a locality far out of their ordinary range of activity. From their numbers the conclusion that they were migrant birds enroute for the southland when swept to sea seems well grounded.

Similar dispersals by the wind are constantly taking place, though perhaps somewhat rarely on so large a scale. The West Indian hurricanes, for instance, carry away many birds and insects when the paths lie over land.

MOSSMAN ON THE PHYSICAL CONDITION OF THE SOUTH ATLANTIC DURING SUMMER.

By H. HELM CLATYON.

[1292 Washington Street, Canton, Mass.]

In the monthly bulletin of the Argentine Meteorological Office there is an interesting study of "The Physical Condition of the South Atlantic during Summer," by Robert C. Mossman.[1] This study of Mr. Mossman was intended chiefly as a study of the observations made by the relief ship going to and fro between Buenos Aires and the Orcadas (South Orkneys) sent by the Argentine Government each year to carry a party of new observers and to bring back the observers of the previous year from the most southern meteorological station in the world, which has been maintained by the Argentine service since 1903. With characteristic thoroughness, Mr. Mossman has combined these data with all the accessible data for that region and produced a valuable study of the South Atlantic during the summer between latitudes 40° and 60° S. and longitudes 40° and 70° W. The summer for that region is December, January, and February.

He first works out the normal distribution of pressure for the summer. His charts show the well-known centers of high pressure over the oceans at about 30° S. They show also two centers of low pressure near the Antarctic circle, one over Weddell Sea and another to the west of Graham Land, separated by a tongue of higher pressure stretching northward from the Antarctic Continent over Graham Land.

This distribution of pressure furnishes a key to the prevailing winds which are shown by windroses drawn for each 5° square and for each month separately from December to March. The wind frequencies are indicated by the lengths of the arrows and the frequencies of gales from each direction are indicated by the proportions of the arrows shaded.

In an additional chart the fog frequencies are shown for each wind direction during the interval January to March.

In every chart Graham Land is seen to be a windshed dividing the winds which circulate about the low pressure in Weddell Sea and the low pressure to the west of Graham Land. On the west side of Graham Land there is a distinct maximum of northeast winds in summer, while on the east side the prevailing winds are from south and southwest.

In regard to the fogs in that region he says: "When a warm wind blows over cold water, the fog is generally very dense near the surface of the water, but has very little height and occasionally it is possible to see over it from the masts of a ship. On the contrary, when a fog is produced by the passage of a cold wind over water at a higher temperature the fog extends to much greater heights, but the base does not always reach the earth's surface; so that the visibility from the deck of a ship is very different in the two cases."

The curve of frequency of fog for each hour at the Orcadas shows a maximum frequency between 8 p. m. and midnight and a minimum frequency at 2 p. m.

In examining water temperatures he found very marked falls of temperature between about 48° and 50° south latitude and finds its explanation in the sharp contrast between the Brazilian Current and the Antarctic Current, which meet about those latitudes.

A diagram is given showing the duration of ice for each year at the Orcadas from 1903 to 1920, and a closing chart is given showing the extreme northern limit of floating icebergs and the line of greatest density of icebergs in so far as they have been observed.

[1] Las condiciones fisicas del Atlantico sur entre el Rio de la Plata y las islas Orcadas del sur durante el veran Boletin Mensual, Año IV, N°. 5, Mayo de 1919, Oficina Meteorológica National, Buenos Aires, 1922.

NOTES, ABSTRACTS, AND REVIEWS.

FURTHER MEASUREMENTS OF STELLAR TEMPERATURES AND PLANETARY RADIATION.

By W. W. COBLENTZ, Physicist.

[U. S. Bureau of Standards, Washington, Oct. 7, 1922.]

[Author's abstract.]

During the past summer, through the generosity of the Lowell Observatory, Flagstaff, Arizona, who financed this research, a further opportunity was presented to continue the measurements of 1921, relating stellar temperatures and planetary radiation. Especial acknowledgement is due Dr. C. O. Lampland for kindly operating the telescope.

The speaker reported a verification of the estimates presented before this society [1] (the meeting of December 17, 1921) of the temperatures of 16 stars as determined from their spectral energy distribution, which was obtained by means of a new spectral radiometer, consisting of a series of transmission screens and a vacuum thermocouple.

By means of these screens, which, either singly or in combination, had a uniformly high transmission over a fairly narrow region of the spectrum and terminating abruptly to complete opacity in the rest of the spectrum, it was possible to obtain for the first time the radiation intensity in the complete stellar spectrum as transmitted by our atmosphere.

The recent measurements of the spectral radiation components, made principally on the sun, the temperature of which was used as a standard of comparison, verify the previous measurements of stellar temperatures which range from 3000° K. for red, class-M stars, to 12000° K. for blue, class-B stars.

Planetary Radiation.—The thermal radiation emitted from a planet as a result of warming by exposure to solar radiation, including heat which may be radiated by virtue of a possible high internal temperature of the planet itself, is essentially of long-wave lengths 7μ to 12μ. Hence, by means of a 1-cm cell of water, interposed in the path of the total radiation emanting from the planet, this long-wave-length radiation can be separated from the reflected solar radiation, and in this manner a measurement obtained of the energy reradiated. If there is planetary radiation then the water cell transmission will be less than that of direct solar radiation.

It was observed that the water cell transmission of the total radiation emanating from Jupiter is practically the same as that of the direct solar radiation. From this it appears that the outer atmosphere of Jupiter does not radiate appreciable long-wave-length infra-red energy as the result of warming by solar rays, and that the atmosphere is sufficiently thick and opaque to trap all the energy reradiated as the result of warming of its interior by solar radiation, or by internal heating, if the interior of Jupiter is still highly heated.

The radiometric measurements on Venus, Jupiter and Saturn are in good agreement with similar measurements made at Mount Hamilton, Calif., in 1914, showing a decidedly lower transmission of radiation through the water cell, in the case of Venus and Saturn.

The intensity of the planetary radiation increases with decrease in the density of the surrounding atmosphere and (as interpreted from the water cell transmissions) in per cent of the total radiation emitted, is as follows: Jupiter (0), Venus (5), Saturn (15), Mars (30) and the Moon (80).

The water-cell transmission of the radiations from the southern (50.6 per cent) and northern (53.1 per cent) hemispheres of Mars should be, and are, higher (i. e., the planetary radiation is lower) than that of the radiations emanating from the equatorial (47.3 per cent) region, owing to the depletion of the reradiated energy by the greater air mass. Moreover, the intensity of the planetary radiation from the northern hemisphere of Mars was found to be less than from the southern hemisphere. This is to be expected in view of the observed cloudiness over the northern hemisphere, which is approaching the winter season and hence is at a lower superficial temperature.

The radiometric measurements on Mars are of especial interest in view of the question of the temperature of this planet.

The calculations of Lowell, based on the heat retained, give a mean temperature of 9° C. for the surface; while another calculation gives a temperature of 22° C. He points out that, owing to cloudiness, only 60 per cent of the incident solar radiation is effective in warming the earth, while 99 per cent is effective in warming the surface of Mars.

In a recent discussion in *Popular Astronomy* of climatic conditions on Mars, inferred from phenomena generally observed on the planet, Pickering estimates the mean annual temperature at +20° F. as compared with the mean annual temperature of the earth of +59° F. (15° C.). At night the Martian temperature is below 32° F. (0° C.) and at noon it is perhaps 60° to 70° F. (15° to 20° C.). These estimates are arrived at from the appearance and disappearance of snow and frost during the course of the Martian day and from the fact that snow is never seen on the equator of Martian noon.

The radiometric measurements are in agreement with the calculations of Lowell and with the arguments recently set forth by Pickering, showing a considerable rise in temperature of the surface of Mars.

Probably the most convincing experimental observations of the range of temperature of the moon are those of Langley and Very and, later, those of Very. These measurements indicate inferred effective lunar temperatures ranging from 45° C. to over 100° C. The calculated value, using recent data on the solar constant, indicates a lunar temperature of 82° C. When we consider that 30 per cent of the total radiation emanating from Mars is of planetary origin, as compared with 80 per cent from the moon, and that all the evidence shows that the lunar surface becomes appreciably warmed, it appears that there is also a considerable temperature rise (10° to 25° C.) of the surface of Mars as calculated by Lowell. So, whether or not we accept the view that vegetation can exist on Mars, the radiometric measurements confirm other meteorological data, showing that at Martian noon the snow is melted, which could not happen if the temperature were −39° C., as some have calculated.

As for the views held by some of the possibility of vegetation growing on Mars, much depends upon whether we think of palm trees growing in our Tropics or the mosses and lichens which thrive on the apparently bare piles of volcanic cinders of Arizona and under our Arctic snows.

[1] Philosophical Society of Washington.

THE ACCURACY OF FORECASTS.[1]

By JEAN MASCART.

[Abstracted from *Comptes Rendus* (Paris Acad.) Oct. 16, 1922, pp. 627-629.]

There are two distinct tendencies in forecasting, one toward general, long-range forecasts, and the other toward very specific, short-period forecasts.[2] The use for which the forecast is made largely determines this tendency. The verification of the forecast is always a troublesome feature, for weather which may be favorable to one interest may be disagreeable to another. To be verifiable, the forecast should be precisely worded, for in a general forecast some part of it is almost certain to be verified.

Robert H. Scott, former head of the English Meteorological Office, stated that a verification of 70 per cent of the forecasts should be considered creditable. Sir Napier Shaw gives a figure of 56 per cent for forecasts 36 hours in advance. This leads the author to conclude that if claims of accuracy as high as 80 to 95 per cent are made they must be either utterly fantastic or based upon very general forecasts.

Rouch found upon testing Köppen's assertion made a long time ago that the weather tends to preserve its character, and hence that the weather of to-morrow will resemble the weather of to-day, that of 100 forecasts, 40 were good, 40 were fair, and 20 were bad. This is somewhat lower than was claimed by Köppen for certain forecasting rules which were not made public. One is left in doubt, therefore, as to what constitutes a satisfactory accuracy of verification.

It has often been loosely stated that on the basis of chance one should be able to forecast with 50 per cent accuracy. The author has tried this out in three experiments, using very precise forecasts, as follows:

(1) A person names a certain date at random, and a second person writes a forecast. This was done for a period covering more than six years. The accuracy was found to vary with the season, but in the mean the verification gave an accuracy of 52.2 per cent.

(2) Given a list of all the days in the year, a forecast is written for each. The accuracy varied from 50 per cent in December to 68.8 per cent in June.

(3) Based upon the statistics of 70 years, a forecast of rain positively worded—rain or no rain—gave a verification of 45.6 per cent in December to 66.7 per cent in June, a mean for the year of 54.4 per cent.

In the above experiments (1) and (2) the forecaster was familiar with the locality and its climate.

It seems from these considerations that 60 per cent is a reasonable lower limit for the satisfactory verification of forecasts upon the condition that the forecasts are very precise.

The author concludes upon the basis of his experience that an accuracy of 80 per cent in regional forecasts for 36 hours in advance is entirely to be hoped for.—*C. L. M.*

[1] La proportion des réussites dans la prévision du temps.

[2] The author implies that the tendency toward long-range forecasting is characteristic of work in the United States, owing to the agricultural and economic demands, and he cites the weekly forecast issued each Saturday. While it is true that this forecast has important bearing upon activities in the fields mentioned, it must not be forgotton that the short-time forecast for the use of aviation and other interests is given even greater attention by forecasters and students in the United States.

ON A WIDE-ANGLE LENS FOR CLOUD RECORDING.[1]

By W. N. BOND.

[Abstracted from *Philosophical Magazine*, 6th series, No. 263, November, 1922.]

The special feature of this lens is that its field of view embraces a complete hemisphere, so that if the lens is arranged to face vertically upward all clouds visible may be recorded photographically on a single flat plate or film. The resultant photograph is circular, the clouds at the zenith being reproduced at the center of the circle and those near the horizon appearing near the edge of the circle. The resultant image differs from the true image by a very small amount.—*A. J. H.*

CONCERNING A METHOD FOR THE DETERMINATION OF PERIODS.

By E. RUBENSTEIN.

[Abstracted from *Meteorologische Zeitschrift*, September, 1922, pp. 272-276.]

In 1911 and 1913, W. Schmidt published papers relating to the determination of long periods in meteorological data[2] to which the present author takes exception.

[For the reader's information, the following brief abstract from the second paper mentioned above, gives the nature of Schmidt's method:

Given a series of values $a_1, a_2, a_3, \ldots$ we may write the differences of the individual values from the mean of the series, a, as

$$a_1 - a = a'_1$$
$$a_2 - a = a'_2$$
$$\ldots$$

Adding these values, step by step, we obtain,

$$b_1 = a'_1$$
$$b_2 = b_1 + a'_2$$
$$\ldots$$

Carrying the process further, we may take the difference between individual values $b_1, b_2, b_3, \ldots$ and their mean b, thus obtaining the values $b'_1, b'_2, b'_3, \ldots$ just as $a'_1, a'_2, a'_3 \ldots$ were obtained above. Similarly, this will lead to the values

$$c_1 = b'_1$$
$$c_2 = c_1 + b'_2$$
$$\ldots$$

Thus the various series b and c are closely related to the original data, and constitute, respectively, first and second integrations of the original function.

The original amplitude A when the integration embraces n intervals becomes $nA/2\pi$, and thus n is related to the amplitude of the curve representing the integral. If the operation is repeated, i. e., if the second integration is performed, the amplitude becomes $n^2A/4\pi^2$. Thus the amplitude varies directly as the square of the

[1] Cf. Fassig, O. L., MO. WEATHER REV., 43:274.

[2] Nachweis von Perioden langer Dauer. *Met. Zeit.*, 1911, pp. 401-407; *ibid.*, 1913, pp. 392-394.

number of intervals embraced. In the integration described above the curve of the second integration is displaced above the original curve so that a maximum in *a* implies a minimum in *c*.]

The present author states this as follows:

Given the so-called quasi-periodic function

$$y = A_0 + \sum_{k=1}^{k=n} A_k \sin\left(\frac{2\pi}{T_k} t + \varphi_k\right)$$

which will be periodic if T_1, T_2, $\cdots$ T_k are commensurable; upon twice integrating this function the equation

$$Y = \sum_{k=1}^{k=n} -\left(\frac{T_k}{2\pi}\right)^2 A_k \sin\left(\frac{2\pi}{T_k} t + \varphi_k\right) + \frac{1}{2} A_0 t^2 + C_1 t + C_2$$

is obtained, in which C_1 and C_2 are constants of integration.

It appears that Schmidt did not take into sufficient account the significance of these constants of integration and introduced a fallacy in taking departures from the mean value of the function.

If

$$y = f(t),$$

the mean value of which is M, then

$$y_1 = f(t) - M.$$

Integrating once, we obtain,

$$\int_{t_0}^{t} y_1 dt = F(t) - Mt + C_1.$$

Instead of again integrating this function, we take the departures from the new mean M_2, the new function to be integrated becomes

$$F(t) - Mt + C_1 - M_2 = F(t) - Mt - M_1.$$

Upon integrating, we obtain

$$Y = \int_{t_0}^{t} F(t)dt - [M(t-t_0)^2/2] - M_1(t-t_0) = \phi(t) - [Mt^2/2] - M_1 t + C.$$

Because of the repeated taking of departures from the mean, the quantity C_1 is not effective in the second integration, while the mean M appears in a parabolic term. Thus, a function which is really not periodic may be made to yield a second integral of parabolic form; this might be mistaken for a sine curve, and thus a period be found, which would have no reality.

Several examples of the inefficacy of this form of investigation are given. First, given a certain function,

$$y = \sin 10°t + \sin 30°t,$$

the second integral shows a period which is entirely different from that shown by the second integral of the expression

$$y = \sin 10°t + \sin 30°t - 0.28,$$

which is the function when subtracted from its mean.

Again, taking the departures from the hundred-year mean of temperature at Petersburg and constructing a second integral curve by Schmidt's method, a very long period is demonstrated, which obviously has no existence in the data themselves.

The author concludes that only if it is known a priori that superimposed trigonometrical functions are involved is this method applicable.—*C. L. M.*

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SOLAR OBSERVATIONS.

SOLAR AND SKY RADIATION MEASUREMENTS DURING NOVEMBER, 1922.

HERBERT H. KIMBALL, in Charge Solar Radiation Observations.

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to this REVIEW for April, 1920, 48:225.

From Table 1 it is seen that direct solar radiation intensities averaged very close to normal values for November at all three stations.

Table 2 shows that the total solar and sky radiation received on a horizontal surface averaged close to the November normal at Washington and Lincoln, and considerably below the normal at Madison, the deficiency being due to unusual cloudiness.

Skylight-polarization measurements made on six days at Washington give a mean of 58 per cent, with a maximum of 68 per cent on the 17th. At Madison measurements made on the morning and afternoon of the 16th give a mean of 71 per cent. These are average polarization values for November at the respective stations.

NOTE.—Continuous registration of the total solar and sky radiation received on a horizontal surface, which was interrupted at Lincoln, Nebr., on June 2, 1921, on account of a defect in the Callendar receiver, was resumed on November 7, 1922, the defective receiver having been replaced by one that had been in use at Washington.

Beginning with November 1, the record of the total solar and sky radiation at Washington has been obtained by means of a thermopile of 50 gold-palladium, platinum-rhodium junctions in series, connected alternately to white and black metal rings, exposed horizontally under a hemispherical glass cover. The registration is by means of an Engelhard recording voltmeter, and the standardization has been effected by comparing the thermopile record with readings of the Marvin and the Smithsonian pyrheliometers. A description of the thermopile will be given at a later date.

MEASUREMENTS OF THE SOLAR CONSTANT OF RADIATION AT CALAMA, CHILE.

NOTE.—Data for the above not having been received in time from South America will appear in a later issue.—*Editor.*

TABLE 1.—*Solar radiation intensities during November, 1922.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance. 8 a.m.	78.7° A.M.	75.7° A.M.	70.7° A.M.	60.0° A.M.	0.0°	60.0° P.M.	70.7° P.M.	75.7° P.M.	78.7° P.M.	Noon.
	75th meridian time.	Air mass.									Local mean solar time.
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
November 1...	4.75	.....	0.90	1.03	1.20	1.40	1.10	0.73	0.64	0.55	5.79
8...	6.50	0.73	0.80	1.01	1.17	1.35	.....	.....	0.97	0.89	3.30
9...	4.95	0.71	0.92	1.06	1.23	.....	.....	.....	.....	.....	4.75
10...	4.57	0.87	0.92	1.04	1.25	.....	1.19	0.89	0.60	.....	4.17
17...	4.17	0.69	0.83	0.99	1.16	1.41	1.16	.....	.....	.....	4.17
20...	5.56	0.80	0.93	1.13	1.28	.....	.....	.....	.....	.....	4.57
23...	3.30	.....	0.82	1.00	1.21	1.47	.....	0.96	0.84	0.71	3.45
24...	2.87	0.80	0.91	0.96	1.26	.....	.....	.....	.....	.....	2.49
29...	3.45	0.64	0.79	1.23	.....	.....	.....	.....	.....	.....	3.00
Means.....	.....	**0.75**	**0.87**	**1.05**	**1.22**	.....	**1.15**	**0.86**	**0.76**	**0.72**	.....
Departures.....	.....	**−0.01**	**+0.02**	**+0.04**	**+0.03**	.....	**−0.02**	**−0.09**	**−0.06**	**−0.01**	.....

Madison, Wis.

November 14...	5.17	.....	.....	.....	.....	.....	.....	1.18	.....	.....	4.57
16...	3.45	0.75	0.96	1.15	1.30	.....	.....	1.06	.....	.....	4.57
23...	4.37	1.00	1.11	1.26	1.35	.....	.....	1.24	.....	.....	3.15
Means.....	.....	**(0.88)**	**(1.04)**	**(1.20)**	**(1.32)**	.....	.....	**1.16**	.....	.....	.....
Departures.....	.....	**+0.01**	**+0.03**	**+0.04**	**+0.02**	.....	.....	**−0.01**	.....	.....	.....

Lincoln, Nebr.

November 2...	5.56	0.76	0.87	1.16	.....	.....	.....	.....	.....	.....	7.04
7...	3.45	.....	1.07	1.22	1.43	1.69	1.42	.....	.....	.....	3.30
14...	3.15	.....	0.96	1.07	.....	.....	1.28	1.08	0.91	.....	3.15
15...	3.63	.....	1.13	1.25	1.40	.....	1.35	1.19	1.05	0.93	3.99
16...	4.37	.....	0.97	1.15	1.38	1.64	1.33	1.18	1.06	1.00	5.56
22...	3.30	.....	.....	1.09	1.30	.....	1.29	1.16	1.03	0.93	3.81
23...	4.37	0.93	1.07	1.22	1.39	1.59	.....	1.28	.....	1.04	4.57
24...	2.62	.....	1.24	1.31	.....	.....	.....	1.25	1.13	.....	2.06
28...	3.45	.....	1.10	1.25	1.33	.....	.....	.....	.....	.....	4.37
Means.....	.....	**(0.84)**	**1.05**	**1.19**	**1.37**	.....	**1.33**	**1.19**	**1.04**	**0.98**	.....
Departures.....	.....	**−0.12**	**−0.01**	**−0.02**	**+0.01**	.....	**−0.05**	**−0.01**	**−0.01**	**+0.04**	.....

*Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

Week beginning.	Average daily radiation.			Average daily departure for the week.			Excess or deficiency since first of year.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Nov. 5...	205	106	170	−26	−62	−56	−3,743	−1,576	.....
12...	216	118	191	+9	−32	−22	−3,680	−1,802	.....
19...	214	131	256	+28	−5	+55	−3,485	−1,839	.....
26...	148	131	230	−23	+4	+43	−3,644	−1,811	.....

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The average pressure for November, 1922, was very much below the normal at land stations on the coasts of Newfoundland and Nova Scotia; it was slightly below on Nantucket Island, while at stations on the southern Atlantic coast of the United States, as well as in the Gulf of Mexico, West Indies, Azores, and Bermudas, the departures were small. In the British Isles, however, the positive departures were unusally large, due to two periods of abnormally high pressure, the first occurring from the 12th to 17th and the second from the 21st to the 27th. At London on the 16th the barometer recorded 30.8 inches, and the lowest reading during the two periods was 30.46 inches, on the 12th.

Judging from reports received, fog was somewhat less frequent than usual over the Grand Banks and steamer lanes, while the number of days on which it occurred was not far from the normal off the coast of New England and somewhat above in the vicinity of the British Isles.

Winds of gale force were unusually prevalent over the western and middle sections of the steamer lanes, and during the first part of the month they also occurred off the coast of Europe, and in the last decade over the region between the Bermudas and the American coast.

According to press reports a great deal of damage resulted from unusually heavy gales in European waters on the 1st and 2d. A number of fishing vessels were blown ashore on the coast of France, and some of the large transatlantic steamers were delayed several hours by the unfavorable weather conditions.

Storm logs are as follows:

Dutch S. S. *Batjan*:

Gale began on October 31, wind SW. Lowest barometer 29.85 inches at 2 p. m. on the 1st, wind SW., 9, in latitude 44° 55′ N., longitude 8° 19′ W. End on the 2d, wind WSW. Highest force of wind 9; shifts not given.

British S. S. *Ventura de Larrinaga:*

Gale began on the 1st, wind W, 6. Lowest barometer 29.32 inches, at 2 p. m. on the 1st, wind SSW, 9, in latitude 50° 33′ N., longitude 0° 30′ W. End on the 2d, wind WNW, 4. Highest force of wind 9, SSW.; shifts SSW–WSW.

Danish S. S. *Frederick VIII:*

Gale began on Oct. 31, wind NW. Lowest barometer 28.97 inches, at 4 p. m. on the 2d, wind W., 11, in latitude 58° 30′ N., longitude 0° 50′ W. End on the 3d, wind W. Highest force of wind 11; steady from west.

From the 2d to the 7th turbulent conditions also prevailed over the greater part of the steamer lanes north of the 40th parallel, as shown by the following storm logs:

British S. S. *Ventura de Larrinaga:*

Gale began on the 4th, wind SSE., 6. Lowest barometer 29.18 inches, at 4 p. m. on the 5th, wind W., 7, in latitude 50° 14′ N., longitude 19° 34′ W. End on the 6th, wind NW., 6. Highest force of wind 9, NW.; shifts W. by SW. by N.

American S. S. *Scottsburg:*

Gale began on the 3d, wind SW. Lowest barometer 29.22 inches, at 6 a. m. on the 4th, wind SW., 9, in latitude 47° 35′ N., longitude 39° W. End at 8 p. m. on the 4th, wind NW. Highest force of wind 10, WSW.; shifts SW.–WSW.–W.–NW.

American S. S. *Coldwater:*

Gale began on the 3d, wind NW. Lowest barometer 29.12 inches at 4 p. m. on the 2d, wind NW., 6, in latitude 47° N., longitude 46° W End on the 4th, wind NNW. Highest force of wind 10, NNW.; shifts NW.–W.–NW.

British S. S. *New York City:*

Gale began on the 6th, wind W. Lowest barometer 29.32 inches at 7:35 p. m. on the 6th, wind WSW., 7, in latitude 44° N., longitude 51° 36′ W. End on the 7th, wind NNW. Highest force of wind 9; shifts WSW.–W.–NW.

The strong gales that prevailed over the central portion of the steamer lanes from the 10th to the 14th, were responsible for the loss of the Italian S. S. *Monte Grappa* that was abandoned on the 15th near latitude 44 N°., longitude 40° W.

Storm logs follow:

Swedish S. S. *Braheholm:*

Gale began on the 10th, wind SSW. Lowest abrometer 29.49 inches at 8 p. m. on the 10th, wind SW., 8, in latitude 53° 36′ N., longitude 31° 45′ W. End on the 12th, wind WSW. Highest force of wind 10; shifts SW.–SW. by W.

Swedish S. S. *Braheholm:*

Gale began on the 14th, wind SSW. Lowest barometer 29.92 inches at 8 a. m. on the 14th, wind SSW., 8, in latitude 50° 30′ N., longitude 42° W. End on the 15th, wind WNW. Highest force of wind 10; shifts SSW.–SW.

On the 13th there was also a fairly well developed area of low pressure over the western section of the ocean as shown by following storm logs:

British S. S. *Cheyenne:*

Gale began on the 12th, wind W. Lowest barometer 29.74 inches at 4 a. m. on the 13th, wind NW., 7, in latitude 42° 31′ N., longitude 59° 14′ W. End on the 13th, wind NNW. Highest force of wind 10: shifts NW. by W.–NW.

British S. S. *Saint Andrew:*

Gale began on the 13th, wind SW., 7. Lowest barometer 29.80 inches at midnight on the 13th, wind SW., 9, in latitude 35° 47′ N., longitude 48° 50′ W. End at 10 a. m. on the 14th, wind NW., 6, Highest force of wind 9; shifts SW.–NW.

From the 13th to the 17th an area of low pressure of moderate intensity covered the West Indies, which, according to reports received, was not attended by any unusual weather conditions.

From the 15th to the 18th unusually high pressure prevailed over the eastern end of the steamer lanes, and the observer on board the British S. S. *Oxonian* reported a barometer reading of 31 inches (uncorrected) on the 17th in latitude 50° N., longitude 23° W.

On the 18th winds of gale force were reported from the region between the forty-fifth and fiftieth parallels and the 35th and 45th meridians. Storm log:

British S. S. *Maine:*

Gale began on the 17th, wind SSE. Lowest barometer 29.90 inches at 11 p. m. on the 18th, wind SSE., in latitude 46° 42′ N., longitude 41° 07′ W. End on the 18th, wind N. Highest force of wind 9; shifts SW.–NW.

Charts VIII to XI show the conditions from the 22d to 25th, inclusive, when strong gales prevailed over different sections of the ocean, while on the 23d there was a "norther" in the Gulf of Mexico, accompanied by comparatively high barometric readings.

British S. S. *Maine:*

Gale began on the 21st wind ESE. Lowest barometer 28.74 inches at 4 a. m. on the 22d, wind WSW., in latitude 42° 40′ N., longitude 56° 45′ W. End on the 23d, wind NNW. Highest force of wind 11; shifts WSW.–WNW.

British S. S. *Huntsman:*

Gale began on the 23d, wind NW. Lowest barometer 29.66 inches at 4 a. m. on the 23d, wind NW., 6, in latitude 31° 52′ N., longitude 62° 58′ W. End on the 24th, wind NW. Highest force of wind 9; shifts WNW.–NW.

American S. S. *Sapinero:*

Gale began on the 23d, wind WSW. Lowest barometer 29.22 inches at 10:30 p. m. on the 23d, wind SW., 10, in latitude 36° 30′ N., longitude 47° 55′ W. End on the 24th, wind NW. Highest force of wind 10, SW.; shifts WSW.–W.

American Schr. *Frank A. Morey:*

Gale began on the 23d, wind SSE. Lowest barometer 29.50 inches at 4 p. m. on the 24th, wind NW., in latitude 40° 50′ N., longitude 73° W. End on the 26th, wind N. Highest force of wind 10; shifts not given.

Dutch S. S. *Leersum:*

Gale began on the 24th, wind SE. Lowest barometer 29.15 inches at 8 p. m. on the 24th, in latitude 47° 20′ N., longitude 38° 10′ W. End on the 25th, wind W. Highest force of wind 11; shifts S.–W.

British S. S. *Idaho:*

Gale began on the 24th, wind S. Lowest barometer 28.96 inches on the 25th, wind W., 10, in latitude 45° 41′ N., longitude 52° 41′ W. End on the 25th, wind W. Highest force of wind 10; steady from W.

American S. S. *F. Q. Barstow:*

Gale began on the 22d, wind NW. Lowest barometer 29.93 inches on the 22d, wind NW., 7, in latitude 22° 30′ N., longitude 94° 10′ W. End on the 24th, wind N. Highest force of wind 9, N.; shifts NW.–N.

On the 26th and 27th, while there were no well developed depressions over the ocean, a number of sporadic reports were received from vessels that encountered winds of gale force.

The observer on board the British S. S. *Paul Paix* reports as follows:

From November 25 to December 6 between meridian 36° W., and Bermuda a series of moderate gales in quick succession, causing high confused seas, and irregular changes of wind, was experienced, accompanied by severe squalls. Barometer fluctuating between 29.58 and 30.22 inches.

On the 28th there was a well-developed disturbance central about 5° east of Charleston, S. C., that moved slowly northeastward, increasing in extent; on the 29th the center was near Sydney, N. S., while the storm area extended as far south as the 30th parallel.

On the 28th a second area of low pressure of less intensity and extent was central near latitude 47° N., longitude 35° W. This also apparently moved northeastward during the next two days, although it was impossible to locate its track accurately on account of lack of observations. Storm logs and reports referring to both of these disturbances follow:

American S. S. *Chester Sun:*

Gale began on the 27th, wind W. Lowest barometer 29.45 inches at 6:30 a. m. on the 28th, wind W., in latitude 31° 52′ N., longitude 75° 03′ W. End on the 29th, wind NNE. Highest force of wind 10; shifts about 10 points.

American S. S. *Maracaibo:*

7 p. m. on the 27th, in latitude 33° 20′ N., longitude 73° 10′ W., barometer 29.70 inches, wind NW., 7; weather, cloudy.

7 a. m. on the 28th, in latitude 31° 50′ N., longitude 71° 20′ W., barometer 29.62 inches, wind SSW., 10; weather, raining.

7 p. m. on the 28th, in latitude 31° 40′ N., longitude 71° 10′ W., barometer 29.56 inches, wind WSW., 11; weather, raining.

7 a. m. on the 29th, in latitude 30° 10′ N., longitude 70° 45′ W., barometer 29.98 inches, wind NNW., 7; weather, cloudy. Lowest barometer 29.48 inches at 4 p. m. on the 28th.

French S. S. *Roma:*

Gale began on the 28th, wind S. Lowest barometer 29.32 inches at 11 a. m. on the 29th, wind S., in latitude 38° 48′ N., longitude 58° 30′ W. End on the 29th, wind WNW. Highest force of wind 10, S; shifts S.–NNW.

German S. S. *Bayern:*

Gale began on the 28th, wind SSE. Lowest barometer 29.55 inches at 5 p. m. on the 30th, wind S., 10, in latitude 47° 21′ N., longitude 38° 35′ W. End on the 20th, wind W. Highest force of wind 10, S.; shifts S.–W.

Norwegian S. S. *Foldenfjord:*

Gale began on the 29th, wind SE. Lowest barometer 29.13 inches at 1:30 p. m. on the 30th, wind S., 10, in latitude 42° 18′ N., longitude 55° 56′ W. End on the 30th, wind NW. Highest force of wind 11; shifts S.–W.

NORTH PACIFIC OCEAN.

By WILLIS E. HURD.

The weather over the North Pacific Ocean during November, 1922, indicates the usual increase of storm activity natural to the advancement of the season over the northern area. The comparatively few reports at hand would indicate a quite persistent area of high pressure over the China coast and some storm activity to the eastward and over Japan, especially on the 1st to 4th, 7th to 11th, 18th to 24th, and 24th to 27th. At least three of the four more active storms occurring during these periods were of tropical origin, but they seem to have developed no material energy until well into higher latitudes.

The first of these storms apparently originated near Guam about October 28. Its center was east of Japan on November 1, and on the 2d and 3d was causing gales to the eastward of the Kurils. The Canadian S. S. *Canadian Inventor,* bound from Moji to Victoria, was involved in this storm on the 2d, 3d, and early morning of the 4th, between latitudes 43° 50′ and 44° 50′ N., longitudes 156° 55′ and 160° E. Though the highest wind force she experienced was only 9, yet on the 2d her barometer showed a pressure, corrected, of 28.87 inches.

The cyclone of the 7th-11th apparently formed over the Asiatic continent, early disturbing the weather in the neighborhood of Japan, thence moving northeastward and merging with the Aleutian LOW in Bering Sea on the 11th.

On the 18th a depression was observed to the southward of the Bonin Islands. On the 19th it was over Japan, and during the four or five following days moved northeastward, developing considerable energy. The American S. S. *West Kader* reported a force of 11 from the W., pressure 29.25, on the 23d in 42° 06′ N., 150° 26′E.

The fourth storm of the Far East began as a tropical depression on or about the 24th, and strongly affected Japan on the 26th. On this and the following day several vessels reported strong westerly gales between Honshu and the 160th meridian of east longitude.

Along the northern steamship routes gales were of frequent occurrence throughout the month, and very few vessels accomplished a passage without encountering rough weather. On a voyage from Yokohama toward Victoria the British S. S. *Tyndareus* was in high seas from the 3d, in about 50° N., 165° W., until the 7th, in about 49½° N., 135° W. Until the 6th the observed gales in this area, force 7 to 11, were mostly from NW. to SW., with the center of activity fluctuating from the Aleutians to the Gulf of Alaska. During the 6th, however, the cyclone spread southward from the Gulf, giving lowered pressures along the coast from Sitka to San Francisco and southerly to easterly gales over much of the same region. The Japanese S. S. *Arabia Maru* reported a gale from the SE., force 11, near latitude 49° N., longitude 128° W., on the 3d.

About the 16th of the month a disturbance appeared near 35° N., 160° E. Near here on the 17th the British S. S. *Shabonee* encountered a southeasterly gale, force 11, with lowest corrected pressure, 29.66 inches. On the same date the American S. S. *Algonquin,* Capt. J. C.

Harding, bound toward San Francisco, encountered hurricane winds several hundred miles to the northeastward of the *Shabonee's* position. The observer noted:

The 17th November, 1 p. m. (G. M. T.), latitude 43° 12′ N., longitude 175° 15′ E. Strong east breeze, cloudy, threatening, barometer 29.90 (uncorrected). 4 p. m., SE. gale, wind force 8, barometer 29.43. 8 p. m., SE. storm, wind 11, barometer 28.98. 9 p. m., hurricane wind SE. 12, mountainous and dangerous sea, hove to full speed ahead. 9.30 p. m., wind hauled to SSE., 12, barometer 28.82. 10 p. m., wind hauled to south, sea very rough, barometer rising slowly to 28.84. 11 p. m., wind hauled to SSW., barometer 28.86. 11.30 p. m., wind hauled to SW. by S., barometer 28.86. 12 a. m., 18th, wind hauled to SW., barometer rising slowly. 1.30 a. m., wind gradually hauling to westward, turned ship around before wind, which put ship almost on her daily track. 4 a. m., wind moderating to a strong gale, with the sea very rough.

Many other vessels reported gales over the northern routes on the 17th and from then until the 24th. Among them the Japanese S. S. *Mandasan Maru*, Yokohama toward San Francisco, reported an easterly gale, force 10, in 45° 55′ N., 179° 17′ E., lowest pressure (uncorrected) 28.87 inches, on the 18th. On the 21st the same vessel noted a northwesterly gale, force 11, pressure 29.42 inches, in 46° 02′ N., 169° 38′ W. The condition causing these gales was very widespread, the entire northern and eastern portion of the ocean being occupied by low pressure having two centers of considerable energy, one over the Aleutians, the other south of the Gulf of Alaska.

North Pacific atmospheric pressure during November was characterized by a procession of LOWS, or a fluctuation of low pressure, across the Aleutian area, and a considerable breaking by cyclonic storms or depressions into the usual belt of high pressure in middle latitudes. Several cyclones from the western part of the ocean seem to have merged with the Aleutian LOW. In addition, a considerable depression moved northward from the vicinity of Midway Island on the 26th and was definitely aligned with an Aleutian disturbance in Bering Sea on the 27th. Two low-pressure areas which apparently originated to the eastward or northeastward of the Hawaiian Islands on the 11th and 20th, respectively, also worked their way into the northern semipermanent cyclone. These depressions exhibited comparatively little violence. They were well observed, since they lay on the San Francisco-Honolulu route. The first persisted east of Hawaii until about the 16th; the second merged on the 21st with the great cyclone which spread southward from the Gulf of Alaska and later retreated to the Aleutian area. After the 26th the North Pacific HIGH dominated the weather of the eastern part of the ocean until the end of the month.

Pressure at Dutch Harbor was somewhat above the normal for the month, the average, based on afternoon observations, being 29.64 inches, as compared with a normal of 29.59. The change from the preceding month was +0.17 inch. The highest reading was 30.26 inches, on the 5th, and the lowest, 28.54 inches, on the 3d. At Midway Island pressure was prevailingly below normal, the average for the month being 30.03 inches, as compared with a normal of 30.11. From the 21st to the end of the month the average daily departure was −0.14 inch. The highest reading was 30.34, on the 10th, the lowest, 29.84, during a northwest gale on the 26th. At Honolulu the departure was very small, as usual, being approximately −0.01 inch. The extremes here were 30.13 inches, recorded on the 25th, and 29.82, on the 11th.

Reports received indicate a marked decrease in the percentage of fog over the North Pacific as compared with October. Only a few vessels specifically mention fog and that on scattered dates along the American coast and elsewhere east of the 180th meridian. The report of the Japanese S. S. *Meiyo Maru*, Capt. J. Satow, Callao toward Honolulu, contains the following statement:

From Chilean coast to near Equator experienced thick weather, misty or foggy, on every morning from about 4 to 8.

On the 17th this vessel reported the unusual condition of fog in latitude 0° 27′ N., longitude 103° 59′ W.

SIX TYPHOONS IN THE FAR EAST DURING NOVEMBER, 1922.

By Rev. JOSÉ CORONAS, S. J.

[Weather Bureau, Manilla, P. I., Dec. 2, 1922]

Five typhoons have been shown on our weather maps during the last month of November, although none of them was of any importance for the Philippines. The last typhoon of October which had appeared to the SSE. of Guam on the 28th and 29th near 146° longitude E. and 9° or 10° latitude N. moved NNE. to the E. of Guam; and while its center could be situated at 6 a. m. of October 30 in about 150° longitude E. and 15° latitude N., another atmospheric disturbance made its appearance to the WNW. of Guam in 140° longitude E. and 16° latitude N., moving NNE. first and then NE. On November 1 this first depression or typhoon of November was still noticed to the SE. of the Bonins, when another typhoon developed between Japan and the Bonins not far from 142° or 143° longitude E. and 31° latitude N. It moved northeastward and caused a considerable falling of the barometer and a gale from SSE. and SSW. on board the S. S. *Taiyo Maru* during the night of November 1 to 2, the approximate position of the steamer being at the time of the barometric minimum (29.30 inches) 149° 30′ longitude E. and 35° 04′ latitude N.

It was also on November 1 that a shallow depression was shown by the observations of Yap in about 138° longitude E. and 6° latitude N. It traversed the southern part of the Philippines on November 4 in the form of a low-pressure area of no importance, but once in the China Sea it developed into a real typhoon, and as such it crossed the southernmost part of Indo-China in the evening and night of November 6.

The fourth typhoon of the month was formed on November 9 to the SSW. of Guam near 142° longitude E. and 9° latitude N. It moved NW. between Guam and Yap on November 9 to 10 and inclined northward on November 12 in about 137° longitude E. and 14° latitude N. It is impossible, with the data at hand, to follow the typhoon after the 13th or to decide whether it filled up or not on that day. Before receiving the daily weather maps of Tokio, it was thought that the falling of the barometer and winds observed in the Bonins on the 16th might be attributed to the recurving northeastward of this typhoon. Yet the Tokio maps are not in favor of this supposition, but rather of a new atmospheric disturbance which developed in the neighborhood of the northern Loochoo Islands on the 15th and moved eastward to the north of the Bonins.

The last depression or typhoon appeared on the 11th and 12th about 200 miles east of the Visayan Islands, moving NNW. It remained almost stationary on the 13th east of southern Luzon and continued moving NNW. or N. on the 14th to 16th. We could not follow the disturbance any more after the 16th; it may be that it filled up on that day E. of the Bashi Channel or of southern Formosa.

DETAILS OF THE WEATHER IN THE UNITED STATES.

GENERAL CONDITIONS.

ALFRED J. HENRY.

The most striking feature of the weather of the current month was the failure of the rains generally east of the Mississippi. The drought was exceptionally severe in Pennsylvania, the western portion of which had not received substantial rains since March of the present year. November precipitation is known to be light, especially in the interior. The rather anomalous condition of the current month—drought east of the Mississippi and normal rains in the Plains States and elsewhere to the westward—was doubtless due to the movement, or rather lack of movement, of cyclones which entered the field of observations from the west and morthwest. As will be noted from Chart I, anticyclones had a pronounced tendency to originate and also to stagnate over the northern Rocky Mountain and Plateau regions; outbursts of cold air proceeded thence southeastward and in the majority of cases separated the southern portion of the warm-air sector of cyclonic systems from the northern portion and thus we believe, cyclones, which normally would have moved to the northeast over Tennessee and the Ohio Valley, were deflected to the west and north and eventually passed eastward north of the Lake region—too far north to give rainfall to the States east of the Mississippi. Prevailing high pressure over southeastern States may also have been influential in causing the movement above mentioned.

CYCLONES AND ANTICYCLONES.

By W. P. DAY.

As would be expected, the pressure changes were more active during November than the preceding month. Several typical winter types of pressure distribution made their appearance. The Plateau HIGH was well developed during two periods and several important Alberta HIGHS were plotted. Among the low-pressure areas, important southwest LOWS and South Atlantic LOWS were charted. No tropical storms were noted. The number of cyclones (LOWS) and anticyclones (HIGHS) by types is shown in the table below.

Cyclones.	Alberta.	North Pacific.	South Pacific.	Northern Rocky Mountain.	Colorado.	Texas.	East Gulf.	South Atlantic.	Central.	Total.
November, 1922	6.0	.....	1.0	.....	4.0	1.0	.....	2.0	.....	14.0
Average number, 1892-1912, inclusive	4.0	2.3	0.6	0.4	1.1	1.0	0.4	0.8	1.0	11.6

Anticyclones.	North Pacific.	South Pacific.	Alberta.	Plateau and Rocky Mountain region.	Hudson Bay.	Total.
November, 1922	4.0	.....	6.0	2.0	1.0	13.0
Average number, 1892-1912, inclusive	2.0	0.9	4.0	1.1	0.2	8.2

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FREE-AIR CONDITIONS.

By L. T. SAMUELS.

Free-air observations for the montn presented no striking features of more than local importance, but rather they showed a nearly normal state of affairs, especially as regards free-air winds. Free-air temperatures (see Table 1) showed a general excess as compared with the normal for practically all stations and levels explored by the kites, with the largest departures occurring at Ellendale. At this station, however, a large proportion of the flights was made at a later hour in the day than usual, and therefore at times when the temperature was ordinarily higher.

Relative humidities showed small departures in nearly all cases, and vapor pressure departures conformed generally with those for temperature.

In Table 2 are given the resultant winds and their normal values. The close agreement, in most cases, between the former and the latter is striking, the one exception being Groesbeck, where considerable deviation is found at a number of levels.

The following stations reported velocities of 40 m. p. s. or more:

Station.	November.	Velocity.	Direction.	Altitude.
		m. p. s.		*m.*
Aberdeen, Md.	24	50	WNW.	4,100
Broken Arrow, Okla.	16	40	WSW.	8,000
Do.	22	44	WSW.	10,300
Dahlgren, Va.	24	47	WNW.	3,900
Due West, S. C.	16	59	WNW.	10,000
Lansing, Mich.	9	41	NW.	8,500
Mitchel Field, N. Y.	24	50	WNW.	2,700

Easterly winds at heights above 5,000 meters were observed as follows:

Station.	November.	Station.	November.
Bolling Field, D. C.	1	Key West, Fla.	1, 2, 7, 16, 19
Denver, Colo.	24	San Francisco, Calif.	13, 28
Edgewood, Md.	1	San Juan, P. R.	4, 19
Groesbeck, Tex.	22		

Numerous occurrences in pilot-balloon observations have been noted when the velocity curve takes on an extremely zigzag form, i. e., indicating alternately high and low velocities superimposed, but with no appreciable change in direction. An inspection of the weather charts on a number of days when such conditions were pronounced gave surprisingly consistent testimony to the fact that these cases are characteristic of the region on the dividing lines between a low-pressure area passing off and a high-pressure area moving in. Some instances of the kind occurring this month were the following:

Station.	November.
Drexel, Nebr.	5 (a. m.), 7 (a. m. and p. m.).
Dahlgren, Va.	20 (p. m.).
Mitchel Field, N. Y.	23 (a. m.), and 29 (p. m.).

It seems highly probable that this condition is an accompaniment of the temperature distribution of this particular arrangement of pressure and a more detailed

study of this phenomenon will be made from kite data as soon as opportunity permits.

During the night of the 4th tornadoes occurred in Oklahoma and Colorado. Pilot-balloon observations in the central part of the country on the 4th and 5th showed winds of gale velocities to be general in the upper levels, denoting a disturbance of marked intensity. In connection with the north-northeastward movement of this storm, free-air observations revealed considerable lag in the storm center at 2,000 meters elevation from that at the surface. The surface winds at Drexel and Ellendale on the afternoon of the 5th were W. 12 m. p. s. and W. 5 m. p. s., respectively. Above Drexel they remained westerly with fluctuating but increasing velocity, while over Ellendale they backed rapidly to E. and decreased in velocity, so that at 2,000 meters elevation the wind at the former station was WSW. 24 m. p. s., while at the latter it was E. 2 m. p. s., with upper clouds at this station moving from the same direction. Subsequent observations show this disturbance to have moved slowly, but the true center was too far north to be accurately represented on the weather map. This lag in the upper levels is, of course, to be expected in a cyclone of this type where the effects of pronounced importation of warm or cold air quickly displace the pressure gradient as found at the surface

A chinook occurred at Denver on the 17th and 18th, causing the temperature to remain abnormally high during the night of these dates. Surface winds were westerly during this period and conditions favorable for the air blowing down the mountains to be heated dynamically and overrun Denver as a dry, warm wind. The effect of this is apparent from the thermograph record for this period. Here it is shown that the temperature increased steadily during the evening hours and night of the 17th–18th, ending in a sudden drop of 12° C. at 3 p. m. of the 18th, at which time the surface wind veered from the NW. to NE. and a little later to SE. The hygrograph record for this period is not available, but the fact that the relative humidity of the westerly wind was extremely low, as is typical of chinooks, is practically certain, since at the noon observation it was found to be only 21 per cent, which was the lowest noon reading for the month. Furthermore, a short time after the wind shift and temperature drop occurred, the relative humidity at 5:40 p. m. had risen to 80 per cent, whereas there were but five days during the month when it was higher than that at the evening observation.

Pilot-balloon observations during chinooks are extremely rare, if, indeed, any have been made at all. The one made at Denver, therefore, on the 18th, or about an hour before the chinook came to a sudden end, is of special interest. Unfortunately there are no other pilot-balloon stations sufficiently near Denver to furnish added testimony as to the trustworthiness of this one observation. However, there appear to be many good reasons for accepting it as substantially correct. The velocity is shown to have increased sharply from 9 m. p. s. at the surface to 38 m. p. s. at an elevation of 1,500 meters, above which the wind was blowing in the opposite direction, i. e., from the SE. with a speed of 10 m. p. s. This latter condition obtained to at least 2,800 meters, where the balloon was lost in the haze. The direction curve just before the balloon was lost, however, indicated that the direction still higher was probably northwesterly, which was the direction of the lower clouds.

The observed wind of 38 m. p. s. is of special interest, since it calls attention to the impracticability of computing the gradient velocity from sea-level isobars for elevated regions such as Denver. By computation it is found that the gradient velocity was 19 m. p. s., or one-half of the actual, and the cause of this discrepancy lies obviously in the unavoidable error introduced in reducing the pressure at this station to a sea-level basis, a question that is at present the subject of considerable discussion. It was found by substituting in the gradient wind formula the observed velocity of 38 m. p. s. and solving for the pressure gradient that the latter required a value of 3.2 mb. per 100 km., or nearly double that shown at the surface. It is of interest to note that at the surface the wind *veered* to easterly and was coincident with the abrupt drop in temperature, and it is pointed out that a *backing* of the wind was found in the free air with increase in altitude from a NW. wind at the surface to a SE. wind at 2,000 meters above. It will be noted, therefore, that the wind shift coincident with the drop in temperature occurred first in the free air, and this colder and relatively denser air soon eliminated the chinook and its influences.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during November, 1922.*

TEMPERATURE (°C.).

Altitude, m. s. l. (*m.*)	Broken Arrow, Okla. (233*m.*)		Drexel, Nebr. (395*m.*)		Due West, S. C. (217*m.*)		Ellendale, N. Dak. (444*m.*)		Groesbeck, Tex. (141*m.*)		Royal Center, Ind. (225*m.*)	
	Mean.	Departure from 5-year average.	Mean.	Departure from 8-year average.	Mean.	Departure from 2-year average.	Mean.	Departure from 5-year average.	Mean	Departure from 5-year average.	Mean.	Departure from 5-year average.
Surface	11.8	+1.9	4.9	+1.4	12.2	−0.7	0.9	+3.9	13.1	0.0	6.1	+1.2
250	11.7	+1.9	.....	.....	12.0	−0.7	.....	.....	12.9	0.0	5.9	+1.2
500	10.3	+1.6	4.5	+1.2	10.9	−0.7	1.1	+4.1	12.7	+0.4	4.6	+1.4
750	9.3	+1.4	3.8	+0.9	9.8	−0.7	1.5	+4.5	13.0	+1.3	3.7	+1.4
1,000	9.1	+1.7	3.9	+1.0	9.0	−0.5	1.6	+4.2	12.9	+1.7	2.8	+1.1
1,250	9.0	+2.1	4.0	+1.3	8.5	−0.1	1.5	+3.9	12.0	+1.5	2.8	+1.5
1,500	8.6	+2.3	3.2	+1.0	7.7	0.0	1.3	+3.9	10.9	+1.1	2.2	+1.5
2,000	6.5	+2.0	1.6	+1.1	6.3	+0.1	−0.6	+3.4	8.3	+0.8	0.6	+1.5
2,500	4.0	+1.6	−0.6	+1.2	4.8	+0.7	−2.3	+3.8	6.6	+1.1	−1.2	+1.5
3,000	2.1	+1.9	−3.0	+1.5	2.8	+1.1	−4.6	+4.0	4.4	+1.4	−4.0	+0.9
3,500	−0.3	+2.1	−6.0	+1.3	0.0	+1.3	−7.2	+4.2	1.8	+1.6	−6.4	+0.5
4,000	−3.2	+1.9	−8.5	+1.6	−2.7	+1.6	−9.4	+4.9	−0.4	+2.2	.....	.....
4,500	−5.4	+2.0	−11.0	+1.8	.....	.....	−12.0	+5.0	−2.0	+3.5	.....	.....
5,000	.....	.....	−14.6	+1.1	.....	.....	.....	.....	.....	.....	.....	.....

RELATIVE HUMIDITY (%).

Surface	61	−5	72	0	66	−1	84	+2	78	+3	74	0
250	61	−5	.....	.....	66	−1	.....	.....	75	+2	74	0
500	57	−6	70	+1	63	−2	83	+2	66	−2	74	+1
750	54	−7	66	+2	60	−3	77	+1	60	−4	72	+2
1,000	49	−10	61	+2	59	−3	71	+1	58	−3	70	+4
1,250	44	−11	57	+2	58	−3	68	+3	59	+1	62	+1
1,500	43	−8	55	+2	58	−2	65	+4	61	+6	58	+1
2,000	45	−2	52	+2	48	−2	66	+8	63	+12	52	0
2,500	45	+1	51	+1	42	−1	62	+4	58	+11	44	−4
3,000	43	0	50	−1	40	−1	57	0	46	+3	49	−2
3,500	41	0	50	−2	40	−5	55	−3	40	−2	51	−2
4,000	40	+2	46	−5	37	−8	62	+2	29	−10	.....	.....
4,500	31	+1	45	+1	.....	.....	68	+8	21	−16	.....	.....
5,000	.....	.....	46	+7	.....	.....	.....	.....	.....	.....	.....	.....

VAPOR PRESSURE (*mb.*).

Surface	8.35	+0.14	6.37	+0.57	9.82	−0.44	6.43	+2.04	12.34	+0.35	7.31	+0.56
250	8.28	+0.14	.....	.....	9.66	−0.43	.....	.....	11.83	+0.26	7.27	+0.59
500	7.33	−0.05	6.03	+0.48	8.65	−0.41	6.40	+2.09	10.47	−0.01	6.65	+0.67
750	6.52	−0.29	5.36	+0.34	7.78	−0.36	6.04	+2.05	9.54	+0.09	6.09	+0.72
1,000	6.04	−0.29	5.08	+0.50	7.14	−0.32	5.55	+1.86	8.97	+0.40	5.52	+0.77
1,250	5.53	−0.30	4.80	+0.52	6.62	−0.18	5.19	+1.77	8.70	+1.07	4.96	+0.76
1,500	5.21	−0.03	4.46	+0.49	6.24	+0.03	4.91	+1.74	8.38	+1.58	4.41	+0.68
2,000	4.64	+0.44	3.81	+0.51	4.55	0.00	4.52	+1.76	7.30	+2.02	3.36	+0.32
2,500	3.73	+0.47	3.21	+0.44	3.69	0.00	3.83	+1.46	5.54	+1.55	2.20	−0.13
3,000	2.92	+0.26	2.62	+0.27	2.91	−0.04	3.24	+1.27	3.36	+0.50	2.14	+0.05
3,500	2.24	+0.26	2.13	+0.20	2.43	−0.11	3.01	+1.39	2.01	−0.12	1.93	+0.22
4,000	1.63	+0.30	1.65	+0.12	1.69	−0.35	3.01	+1.67	0.54	−0.84	.....	.....
4,500	0.94	+0.26	1.37	+0.29	.....	.....	2.91	+1.66	.....	.....	.....	.....
5,000	.....	.....	1.04	+0.37	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 2.—*Free-air resultant wind directions and velocities (m. p. s.) during November, 1922.*

Altitude, m. s. l. (m.)	Broken Arrow, Okla. (233m.)				Drexel, Nebr. (396m.)				Due West, S. C. (217m.)				Ellendale, N. Dak. (444m.)				Groesbeck, Tex. (141m.)				Royal Center, Ind. (225m.)			
	Mean.		5-year average.		Mean.		8-year average.		Mean.		2-year average.		Mean.		5-year average.		Mean.		5-year average.		Mean.		5-year average.	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S. 40° W.	1.4	S. 40° W.	1.1	S. 73° W.	2.7	S. 87° W.	1.4	N. 72°W.	2.6	N. 84°W.	2.2	N. 35°W.	3.0	N. 44°W.	2.2	N. 61° E.	0.9	N. 41° E.	0.3	S. 46° W.	3.5	S. 55° W.	2.6
250	S. 38° W.	1.5	S. 34° W.	1.2					N. 81°W.	1.9	S. 88° W.	1.8					N. 65° E.	1.7	N. 78° E.	0.6	S. 46° W.	4.0	S. 52° W.	2.8
500	S. 28° W.	2.5	S. 21° W.	2.2	S. 75° W.	3.3	S. 87° W.	2.0	S. 74° W.	0.9	S. 74° W.	1.6	N. 41°W.	3.1	N. 55°W.	2.3	N. 88° E.	2.9	S. 33° E.	0.9	S. 58° W.	6.4	S. 53° W.	4.6
750	S. 30° W.	3.5	S. 25° W.	3.2	S. 81° W.	4.4	S. 89° W.	3.5	N. 86°W.	1.4	S. 78° W.	2.3	N. 43°W.	4.7	N. 55°W.	3.5	S. 79° E.	3.0	S. 15° W.	1.3	S. 62° W.	8.0	S. 60° W.	6.2
1,000	S. 50° W.	4.5	S. 38° W.	3.7	S. 86° W.	5.9	S. 84° W.	4.8	N. 86°W.	2.7	S. 82° W.	3.1	N. 49°W.	5.7	N. 62°W.	4.3	S. 69° E.	2.2	S. 44° W.	2.1	S. 66° W.	9.2	S. 65° W.	7.2
1,250	S. 55° W.	5.4	S. 48° W.	4.6	S. 87° W.	6.9	N. 89°W.	5.7	N. 89°W.	3.9	S. 87° W.	4.6	N. 56°W.	6.2	N. 66°W.	5.0	S. 28° E.	0.7	S. 59° W.	3.0	S. 71° W.	10.1	S. 68° W.	8.2
1,500	S. 54° W.	6.3	S. 57° W.	5.1	S. 79° W.	8.3	N. 88°W.	6.8	S. 87° W.	5.5	S. 88° W.	6.0	N. 62°W.	6.7	N. 66°W.	6.3	S. 39° W.	2.1	S. 67° W.	4.0	S. 73° W.	10.9	S. 71° W.	8.8
2,000	S. 62° W.	5.9	S. 64° W.	6.9	S. 84° W.	10.1	N. 84°W.	7.7	S. 85° W.	7.2	S. 86° W.	8.4	N. 63°W.	8.5	N. 66°W.	8.2	S. 56° W.	4.4	S. 69° W.	5.7	S. 83° W.	12.1	S. 78° W.	10.3
2,500	S. 73° W.	7.3	S. 73° W.	7.7	N. 87°W.	11.7	N. 81°W.	9.4	S. 81° W.	9.6	S. 82° W.	10.5	N. 59°W.	12.0	N. 65°W.	11.1	S. 66° W.	5.9	S. 84° W.	7.5	S. 84° W.	13.1	S. 80° W.	12.4
3,000	S. 64° W.	9.6	S. 72° W.	9.6	S. 87° W.	13.5	N. 79°W.	10.7	S. 88° W.	12.7	S. 85° W.	13.8	N. 57°W.	12.5	N. 66°W.	12.9	S. 62° W.	8.2	S. 83° W.	9.0	N. 87°W.	13.0	S. 88° W.	14.1
3,500	S. 62° W.	11.2	S. 70° W.	10.1	N. 75°W.	12.6	N. 76°W.	11.4	S. 84° W.	13.8	S. 86° W.	14.7	N. 53°W.	13.5	N. 65°W.	13.8	S. 56° W.	9.8	S. 69° W.	11.4	N. 74°W.	19.4	N. 89°W.	12.9
4,000	S. 70° W.	11.0	S. 77° W.	11.8	N. 83°W.	14.6	N. 80°W.	13.3	N. 81°W.	17.7	N. 82°W.	16.3	N. 68°W.	15.3	N. 62°W.	12.4	S. 18° W.	9.2	S. 64° W.	9.3				
4,500	S. 58° W.	11.4	S. 61° W.	14.2	N. 79°W.	16.2	N. 86°W.	14.5	W.	19.3	N. 76°W.	18.0	N. 68°W.	16.8	N. 50°W.	15.7	S. 28° W.	9.3	S. 62° W.	9.7				
5,000	S. 45° W.	12.3	S. 45° W.	12.3	S. 45° W.	18.6	S. 85° W.	15.6									S. 22° W.	7.5	S. 68° W.	10.1				

THE WEATHER ELEMENTS.

By P. C. DAY, Meteorologist, in Charge of Division.

PRESSURE AND WINDS.

During November the continental high pressure, common to the colder period of the year, usually assumes a more definite type than is apparent during the preceding month, and the somewhat permanent high areas over the southeastern States and in the far Northwest increase both in area and magnitude. At the same time there is a general increase in pressure over that existing during October in practically all portions of the country. The only exception to this is found over extreme northwestern Washington, where the increasing storm activity, due to the approach of winter, tends to reduce the average pressure below that of October.

For the present month pressure in both Canada and the United States was everywhere greater than during the preceding month, and the differences were distinctly larger than is usually the case, particularly over the far Northwest and to a somewhat less extent in all southern districts. Pressure averages were likewise well above the normal over all western and southern districts, but they were slightly less than normal over portions of the upper Mississippi Valley, Lake region, and to the eastward.

While changes in atmospheric pressure were rapid and cyclones and anticyclones moved across portions of the country at more frequent intervals than is usual, the pressure gradients were mainly insufficient to produce high winds. On the morning of the 4th, however, a storm that had moved from northern Arizona and southern Utah to southeastern Colorado during the preceding 24 hours developed conditions favorable for local high winds in the middle Plains and adjacent regions during that and the following day, a severe tornado being reported from eastern Colorado on the 4th, attended by the loss of several lives and heavy damage to property. (A more complete account of this storm will be found on page 605 in this REVIEW.)

Some high winds occurred over the North Atlantic coast sections during the last decade of the month, and at the close a severe storm was approaching the Great Lakes, and high winds prevailed from the lower Missouri Valley to the Lake Superior region.

The high-pressure area over the Southeastern States had its center of greatest pressure in the southern Appalachian Mountain district and greatly influenced the prevailing winds to eastward of the Mississippi River, the winds around the central high area assuming the usual anticyclone movement. Likewise there was the usual movement around the high area central over the northern Plateau and northern Rocky Mountain region. The prevailing winds were usually from the northwest in the upper Missouri Valley and from southerly points in the middle Plains. In the far Southwest and in central and southern Texas they were mainly from northerly points.

TEMPERATURE.

As was the case in October, the outstanding feature of the weather of the month was the continued absence of uncomfortable cold over the districts from the Rocky Mountains eastward until near the end. Over the more western districts, however, the weather was nearly continuously colder than normal during most of the month.

The first week of the month had temperatures above the normal from the middle portion of the Great Plains eastward to the Atlantic coast, the period being particularly warm in the great central valleys. West of the Rocky Mountains cold weather persisted, the weekly averages ranging from 6° to 9° daily below the normal over much of the Plateau region.

During the second and third weeks temperature conditions remained much as in the first week, though not quite so warm over the eastern districts and slightly colder than the preceding week in the central and northern Rocky Mountain regions.

The last week of the month brought a general reversal of temperature conditions, the averages falling below normal in the districts to eastward of the Mississippi River for the first time in a number of weeks, but continuing unusually warm in the Missouri Valley and adjacent areas. The week continued cool in the far Northwest, where almost constant cold had prevailed during the preceding portions of the month.

The average temperature for the month as a whole was above normal in practically all portions of the United States and Canada to eastward of the Rocky Mountains, and decidedly so from Kansas and Missouri northward, where the monthly means ranged from 5° to 10° above

normal. West of the Rocky Mountains the month was, generally speaking, cold and disagreeable. At some points the temperature remained below normal throughout nearly the entire 30 days and the averages were among the lowest of record for November.

The warmest periods of the month were during the first few days over the greater part of the country, although warm periods occurred in other parts of the month, but generally during the first two decades. Maximum temperatures above 90° were observed in most of the Southern States, while in some of the Northern States they did not rise higher than 70°.

Minimum temperatures were not unusually low as compared with November of some previous years, the lowest for the month occurring usually during the last decade. Freezing temperatures were reported from all the States, and readings below zero were reported from practically all the western Mountain States. The lowest observed, −23°, was reported from the mountain districts of Colorado.

PRECIPITATION.

The marked shortage of precipitation that had persisted during much of September and October over extensive areas in the central and eastern portions of the country continued throughout November in most of the States from the Mississippi River eastward.

While this shortage of moisture fortunately was not materially injurious to vegetation, due to lateness of the season, save in some of the trucking districts of the South Atlantic and East Gulf coast regions, the domestic supply of water was becoming alarmingly low in some of the more eastern districts. Farmers in many localities were compelled to haul water for both household and stock needs, the water supply of many cities was greatly depleted, and power plants and factories depending on water were being greatly inconvenienced by the diminishing supply. In portions of Pennsylvania, particularly the more eastern portions, the precipitation during the month was the least that has occurred in November for a hundred years or more, and the combined precipitation for the four months August to November, inclusive, of the present year was also the least for these four months in a like period.

At Charleston, S. C., it was the driest November in more than 50 years, and a number of stations in that State, as well as in Georgia and Florida, reported an entire absence of rainfall during the month.

While precipitation was markedly deficient over the more eastern sections, those immediately west of the Mississippi River and extending thence to the Rocky Mountains, had in the main abundance of moisture, and in certain localities too much for present needs. In portions of the Great Plains region the precipitation was the heaviest for November in 50 years or more, the amounts in the central and eastern portions of Kansas and Oklahoma ranging up to 6 to 8 inches and in a few cases to nearly 10 inches.

In the far southwestern districts precipitation, though not so heavy as farther east, was nevertheless mainly above normal, and in some instances materially so. In portions of New Mexico the first appreciable precipitation since June occurred, relieving somewhat the water shortage that had existed so long.

In the far Northwest precipitation was sufficient for present needs, but the total falls were mainly less than normal, and in portions of Washington the month was the driest November of record.

The greatest precipitation for the month occurred in extreme southern Louisiana, where nearly 18 inches were measured. No precipitation occurred at a few points in Georgia, Florida, California, and Nevada.

SNOWFALL.

The snowfall of November was generally not heavy, especially to eastward of the 100th meridian. However, in parts of the Rocky Mountain States, the Dakotas, and western Nebraska there were some heavy falls early in the month, particularly on the 4th and 5th, when the falls over eastern Wyoming, western South Dakota, and adjacent districts were unusually heavy. In the Black Hills region the depths ranged from 3 to 4 feet on the level, and much loss of live stock resulted. At Lander, in central Wyoming, from the snowfall late in October the ground remained constantly covered till well into December, owing largely to the decidedly low temperatures that prevailed and to the moderate additional falls that occurred. This snow cover necessitated an unusual amount of feeding for the time of the year. In the Sierra of California some heavy snowfalls occurred from the 6th to 10th. At Summit, elevation 7,017 feet, 6 feet of snow was measured during that period, and there were greater falls at some of the higher elevations.

Over the upper Mississippi Valley and the districts to eastward there was considerably less snowfall than the November average, except in a few small areas. During the cold weather of the closing week a little snow and sleet, usually less than 2 inches, fell over the south-central portions of Alabama and Georgia, reaching some points where snow had not previously fallen for a long period.

For the month, as a whole, snow occurred over the greater part of the country, although the amounts east of the Rocky Mountains were mainly surprisingly small considering the wide extent of its occurrence.

RELATIVE HUMIDITY.

Despite the generally dry conditions existing during the month from the Ohio and lower Mississippi Valleys eastward, including New England, and the unusual warmth that prevailed in the same region during the greater part of the month, the average relative humidity was not materially lower than normal; in fact, over some of the drier regions of the Southeast the percentages were locally above normal. In the trans-Mississippi region relative humidity was mainly greater than the normal, the percentages being unusually high in the western Plains and Rocky Mountain districts. On the immediate Pacific coast the relative moisture content of the atmosphere was distinctly less than normal.

SEVERE LOCAL STORMS.

[The table herewith contains such data as have been received concerning severe local storms that occured during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau.]

Place.	Date.	Time.	Width of path (yards).	Loss of life.	Value of property destroyed.	Character of storms.	Remarks.	Authority.
Webb City, Mo	1	A. m.		1	$75,000	Tornado	Houses demolished; 15 hurt	Evening Star (Washington, D. C.); Star (Oneonta, N. Y.).
Belleville, Ill	1	10 a. m.			30,000	Wind	Smokestack, 60 feet high, blown down, wrecking factory building; 6 persons injured.	Official, U. S. Weather Bureau; Globe Democrat (St. Louis, Mo.).
Eastern Colorado	4	A. m.	100–1,760	5	130,000	Two tornadoes	Heavy damage to buildings, household goods, livestock; many injured.	Official, U. S. Weather Bureau; Star Journal (Peublo, Colo.).
Southern and north-central Kansas.	4	P. m.		1		Tornadoes and wind.	Buildings and wire lines blown down; tornadoes in Clark and Mitchell Counties; man killed in Butler County.	Official, U. S. Weather Bureau; Wichita Eagle (Kans.).
Creek County, Okla	4	P. m.	100–880	6	500,000	Tornado	Houses and oil rigs wrecked	Tulsa Daily World (Okla.); Wichita Beacon (Kans.); Washington Herald, (D. C.).
Rapid City, S Dak., and vicinity.	4–5					Wind and snow	Railway and highway traffic impeded	Official, U. S. Weather Bureau.
New York State	23–24			2		Wind	Eight barges, carrying 130,000 bushels of wheat, wrecked on Lake Oneida.	Do.
Eastern and southern Minnesota.	30	P. m.		1		do	Buildings, trees, windows, etc., damaged	Official, U. S. Weather Bureau; Pioneer Press (St. Paul).

STORMS AND WEATHER WARNINGS.

EDWARD H. BOWIE, Supervising Forecaster.

The weather and storm conditions were not in anyway unusual during the month of November. It was noted, however, that there was a tendency for all areas of high barometer east of the Rocky Mountains to move well to the south of east before passing into the Atlantic after leaving the continent and that few of these were attended by temperatures much below the normal. For a considerable part of the month the pressure remained high over the northern Rocky Mountain and northern Plateau regions, a condition which is not infrequently observed in these regions after the first general fall of snow over the mountains of these regions. Moreover, the LOWS, or cyclones, of the month showed a marked inclination for those of the Alberta type to move eastward in high latitudes and for those which developed over the Plateau and southern Rocky Mountain regions to move northeastward toward the upper Lake region and thence along but north of the northern border to the Canadian Maritime Provinces and Newfoundland. As a matter of fact, it was not until near the end of the month that the tendency for cyclones to follow the northern border eastward from the Great Lakes to Newfoundland was departed from, or, to be specific, on the 26th a cyclone of the Alberta type moved rapidly southeastward to the South Atlantic coast and thence quite rapidly northeastward to the Grand Banks, where it became a disturbance of marked intensity with a central pressure below 29 inches.

It is also notable that during the last decade of the month the distribution of pressure underwent a marked change over the Alaskan area and the North Pacific Ocean, when there was a reversal of the pressure gradient that normally is found to be the order over these regions, i. e., high barometer off the California coast and low barometer to the northward. On and about the 21st and 22d a LOW of great magnitude covered the ocean south of Alaska and the Aleutian Islands, and at the same time the pressure rose to above normal over the continent and the Bering Sea. This change in pressure distribution was of such a nature that it was confidently expected that following shortly thereafter the tracks and types of cyclones of the United States could not but change to meet the newly developed pressure distribution. Hence on the 23d statement was issued for the press to the effect that relief from the drouth of several months duration in the middle Atlantic States might be expected in the near future. A cursory examination of the weather charts of the United States for the two weeks following the day on which this prediction was made will disclose a very marked shift southward of the storm tracks and, further, will disclose the the fact that all of the cyclones that followed were attended by rains in considerable quantities not only in the middle Atlantic States but generally east of the Rocky Mountains. Another notable phenomenon was the persistence of high barometer during the greater part of the month over the British Isles and southwestern Europe.

WASHINGTON FORECAST DISTRICT.

Few warnings, other than those for frosts in the southern and occasionally freezing temperatures in the middle and northern States of the Washington Forecast District, were required; but storm warnings were displayed on the 23d, 27th, 28th, and 30th for the Middle Atlantic or New England coasts, in connection with disturbances that crossed the continent. No storms of tropical origin occurred during the month in West Indian waters.

CHICAGO FORECAST DISTRICT.

The month was for the most part mild and uneventful throughout the Chicago Forecast District.

Strong winds prevailed on the Great Lakes on only two or three days, and, as a consequence, navigation continued under most favorable circumstances. Several disturbances in the West, as they approached the Great Lakes, seemed to justify storm warnings, but as they reached the Lake region their force was often very quickly dissipated.

The storm-warning service, for this reason, was not as effective as it should ordinarily be expected to be, as warnings were ordered for a few days for some portions of the Lakes when they were not justified.

The storm of November 1, which centered in eastern Kansas with lowest barometer of 29.50 inches at Iola, is a case in point. Warnings were ordered during the day

for Lakes Michigan and Superior, but while the center of the disturbance passed directly over the Great Lakes, its energy was rapidly lost and no strong winds followed. The severe disturbance which covered the Rocky Mountain Region and the Great Plains on the 3d, 4th, and 5th acted in much the same manner as it approached the Lake Region, except that it took a more northerly course, and the storm warnings that were ordered were not justified.

Another storm which had been causing severe conditions throughout the West on the 11th and 12th, including heavy snow, gradually lost its energy in approaching the Great Lakes Region. Northeast storm warnings, however, that were ordered on the morning of the 12th for the southern half of Lake Michigan were justified at Chicago with an onshore wind of 37 miles.

Small-craft warnings were ordered on the morning of the 17th for eastern Lake Michigan and Lakes Huron, Erie, and Ontario, as a disturbance crossed the Great Lakes with its center far to the north, and verifying velocities were registered at a few stations. The strong winds, however, were accompanied by fair weather so that conditions were not in the least critical.

A storm which appeared in the northern Rocky Mountain region on the night of the 17th lost some of its energy as it approached the western Lake Region, but, nevertheless, warnings ordered for Lakes Superior, Michigan, and Huron were verified at a few stations.

While, as I stated before, nearly all of the storms lost their intensity as they reached the Great Lakes, there were two exceptions in the last decade of the month, one on the 23d and one on the 30th. The first of these two storms had no indication of increasing severity. Small-craft warnings were ordered on the morning of the 23d for all lakes except extreme western Superior, and these were changed to storm warnings at 1 p. m., verifying velocities being registered at a large majority of stations.

On the morning of the 28th an extensive barometric depression covered the Canadian Northwest, and on the 29th the head of this storm had reached the Lake Superior region, but a secondary disturbance was then developing over the Great Basin. The latter rapidly became the main disturbance and moved in a northeasterly direction its center passing over Lake Superior on the night of the 30th. Warnings were ordered on the 30th for all lakes except eastern Lake Superior, and at night they were lowered on the western portion of that lake because of the omission of an important word from the Duluth signals which indicated that the storm was rapidly losing force. As an unavoidable consequence of this and the fact that night reports are not received at Chicago from either Houghton, Mich., or Wausau, Wis., the two stations nearest to Duluth and in close proximity to the storm center, the warnings on Superior were not handled in the manner the situation demanded. This is a marked example of the necessity of accurate reports for use in forecasting. Moreover, generally speaking, from the standpoint of the forecaster, the work of handling the storm warnings on the Great Lakes during the whole month was most difficult because of the erratic action and movement of the various disturbances.

No general cold-wave warnings were issued during the month, and frost warnings for only a limited area in the extreme southeastern portion of the region, the latter terminating about the 15th, as there were no crops there after that date susceptible to injury.

Stock warnings were issued for the Dakotas on the 18th and on the morning of the 30th because of the threatening and severe conditions anticipated in connection with the movement of the storms which passed northeastward toward Lake Superior.

Special advices for a week in advance have been sent from the beginning of the month to the Wenatchee Valley Traffic Association, Wenatchee, Wash., in connection with the shipment of fruit across the frontier States of the Northwest, and it has shown in various communications high appreciation of the service rendered.

The Chicago Weather Bureau office is making a special effort to get in even closer touch with the advertising interests in order to better guide these as to the time of publishing and the character of the ads. Many of the advertising managers of large establishments are in daily touch by telephone with the forecaster, and much appreciation has been shown of the service. The following letter received from the H. Paulman & Co. under date of November 23, which handles Pierce-Arrow motor cars and trucks, refers to an instance of such special service:

"We wish to thank you very much for the kind cooperation your department showed us last Saturday in advising us when you expected the first freeze.

"I do not know that we ever got so much consideration from a public department as we did from you, and, while I hope it will not be necessary to bother you again in the future, it would at least be a pleasure to do so."

—*H. J. Cox.*

NEW ORLEANS FORECAST DISTRICT.

The weather was exceptionally mild for the season, and frost warnings were continued longer than usual for the northern portion of the district. Colder weather during the last decade made frost warnings necessary in the interior of the southern portion, and warnings were issued accordingly. The frost warnings were verified except in a few instances characterized by persistent cloudiness.

On the 11th, with moderately low pressure over western Texas and high pressure over the northern and middle Rocky Mountain States, cold-wave warnings were issued at night for the Texas Panhandle and western Oklahoma. The warnings were extended the next morning over Oklahoma, northwestern Arkansas, and the northwestern and north-central portions of east Texas, a hard freeze being predicted for the northern portion of west Texas; and the warnings were given to stockmen. The cold wave occurred over part of the northwestern portion of the district, but was prevented from extending farther by the northward movement of the LOW, a trough of low pressure being maintained over the central portion of the country for two days, while the western HIGH became less intense and pressure increased over the Great Lakes. No other cold-wave warnings were issued or required.

Northwest storm warnings were displayed on the Texas coast because of conditions shown on the 8 p. m. map of the 12th, but were only partially verified, as the area of high pressure diminished greatly in intensity as it moved southward.

Small-craft warnings were displayed on the middle coast of Texas on the 22d and locally by the official in charge at Corpus Christi, Tex., on the 4th, 21st, and 30th. These warnings were justified.

Fire-weather warnings for forested areas in Arkansas and Oklahoma were issued on the 4th and 30th.—*R. A. Dyke.*

DENVER FORECAST DISTRICT.

A LOW which began to develop on the southern Rocky Mountain Plateau on the 1st had moved by the evening of the 3d to northern New Mexico, whence it advanced

northeastward with increasing intensity to Minnesota. This disturbance was attended by snow or rain in all portions of the district, although the precipitation was light in southern New Mexico and southern Arizona and was followed by a cold wave in central Arizona, northeastern New Mexico, and southeastern Colorado.

On the morning of the 4th, when the storm was central over southeastern Colorado, violent local storms occurred in the eastern portion of the State. A tornado that appears to have originated 5 or 6 miles south of Sugar City, in Otero County, moved northward and northeastward through Lincoln, Washington, Yuma, and Phillips Counties, disappearing about 5 miles northeast of Amherst. Three persons were reported to have been killed outright and 10 injured, 2 so seriously that they died the following day. The total property loss was in excess of $130,000.

Warning of a moderate cold wave was issued on the morning of the 4th for south-central and extreme eastern Colorado and southern and extreme eastern New Mexico. On account of the slow northeastward movement of the storm, the verifying limit was not reached in the portions of Colorado mentioned until the morning of the 6th. The fall in temperature in 24 hours amounted to more than 20° in most of eastern New Mexico, but the verifying limit was not quite reached in the southeastern portion of that State.

Another storm that appeared on the north Pacific coast on the 5th moved slowly southeastward to central California and western Nevada by the morning of the 9th and had overspread the northern Rocky Mountain States and the upper Missouri Valley on the 10th. During the 10th this disturbance formed a trough of pressure that extended from the southern Rocky Mountain States to the northwestern portion of the Lake region, with separate centers over eastern New Mexico and southern Minnesota, while a HIGH of considerable intensity developed over Montana. Snow or rain occurred in Utah, northern Arizona, and Colorado between the 9th and 12th, with heavy snow in north-central Colorado on the 11th.

On the morning of the 11th warning of a moderate cold wave was issued for southeastern and extreme eastern New Mexico, and on the evening of that date the same warning was distributed for southeastern Colorado. The warning was fully verified in northwestern New Mexico and southeastern Colorado. While a fall of 18° occurred in extreme southeastern New Mexico during the 24 hours ending at 8 p. m. of the 12th, the limit required for a complete verification was not reached until the following morning, when the coldest weather of the season occurred on the southeastern slope, the temperature falling to 2° at Denver, 6° at Pueblo, and 18° at Roswell.

Light rain in southern New Mexico on the 16th and light snow in northern New Mexico and Colorado on the 16th and 17th attended a moderate LOW which moved from northern Arizona to eastern Colorado on those dates.

Rain again occurred in southern New Mexico on the 21st, 22d, and 23d, and snow fell in northern New Mexico and southern and western Colorado from the 21st to the 24th, due to a most unusual storm which appeared over southwestern Arizona on the 19th and continued over that State and southern California until the 24th, without advancing eastward, a HIGH in the meantime covering the sections to the northward and eastward.

The last storm of the month was a secondary disturbance which began to develop over Nevada on the 27th and remained nearly stationary, increasing in intensity until the 29th, after which it moved rapidly northeastward, its center having advanced to northwestern Nebraska on the morning of the 30th. From the 28th to the 30th precipitation occurred in about all portions of the Denver district.

On the morning of the 29th live stock warnings were issued for western Colorado, extreme northwestern New Mexico, northeastern Arizona, and southeastern Utah, on account of the heavy snow and colder weather indicated for those sections. Heavy snow occurred over all of the area specified on the 29th and 30th, except in extreme northwestern Colorado, with lower though not severely cold temperatures.

Warning of a moderate cold wave was issued on the morning of the 30th for eastern Colorado and southwestern Utah. The warning was fully verified in most of eastern Colorado, but failed of verification in southwestern Utah, where a rapid increase in pressure was not attended by the usual fall in temperature.

No warning was issued in advance of the cold wave which occurred in central Arizona on the 4th. Moderate cold waves without warning also occurred in north-central Colorado on the 11th and 19th.

Freezing temperature was forecast on the morning of the 4th for south-central and southeast Arizona, with killing frost in the extreme southwest portion. On the following morning the minimum temperatures at Phoenix and Yuma were 34° and 38°, respectively, with killing frost at the former station. Frost warnings were also issued for south-central and southeast Arizona on the 6th, 10th, 12th, 18th, 19th, 24th, 25th, 26th, and 27th; for southern Arizona on the 5th, 11th, 13th, 14th, 16th, 17th, 21st, 22d, and 30th, and for south-central Arizona on the 20th and 23d. These warnings were generally verified by the occurrence of frost or frost temperatures, except those of the 27th and 30th.

Heavy to killing frost, without warning, occurred in southwestern Arizona on the 4th, and light frost in south-central Arizona on the 8th.—*J. M. Sherrier.*

SAN FRANCISCO FORECAST DISTRICT.

A large storm appeared over Alaska on the 1st and moved slowly southeastward, with its center several hundred miles at sea, and paralleling the coast until the 9th, when it curved eastward and passed inland over northern California. It gave rain or snow over the entire district from the 6th to the 10th. Another storm from the North Pacific moved inland through British Columbia and caused rain or snow over the North Pacific States on the 16th and 17th. A third storm moved inland through British Columbia giving rain or snow in the north Pacific States on the 27th and 28th. A secondary from this storm formed over the southern Plateau and gave rain in southern California and snow in Nevada on the 29th and 30th.

Storm warnings were ordered as follows: At North Pacific stations on the 3d, 5th, 6th, 15th, 17th, 18th, 21st, and 25th; on the northern California coast on the 6th, and on the southern California coast on the 9th. Advisory warnings were sent to North Pacific stations on the 20th. These warnings were generally verified and are believed to have been justified in all cases.—*G. H. Willson.*

RIVERS AND FLOODS.

By H. C. FRANKENFIELD, Meteorologist.

A further deficiency in rainfall during the month of November over the eastern portion of the country accented an already serious drought situation. Stream flow decreased materially, and in many communities

the supply of water for domestic, agricultural, and commercial purposes was reduced to a dangerous minimum. The situation was especially grave in Pennsylvania, New York, and Maryland, and at the close of the month there was no prospect of early relief.

There were minor floods in the Grand River of Missouri and in Chisholm Creek, a tributary of the Arkansas River, in the vicinity of Wichita, Kans. The flood in the Grand River was caused by heavy rains on November 11 and 12, over south-central Iowa and northern Missouri, and the river at Chillicothe, Mo., rose from 5.9 feet on November 12 to 26.2 feet on November 18, flood stage being at 18 feet. Warnings for a stage of 21 feet were issued on November 13, failure to forecast the higher stage reached having been due to absence of precipitation data from the Iowa portion of the drainage area. The rise came from both branches of the river, but there was no damage of consequence, as the great flood of July, 1922, left nothing more subject to damage from overflow.

The flood in Chisholm Creek, Kans., was due to the same general rain storm, Wichita, Kans., reporting 4.20 inches in 24 hours. The flood waters came entirely from Chisholm Creek, and nearly 3 square miles of North Wichita were covered with water. While the inconvenience caused was great, the damage was slight. As there are no reporting stations on Chisholm Creek, it was impossible to issue warnings of the flood.

The new canal in the Mississippi River at Le Claire, Iowa, was opened for business about the end of the month. The pool formed by the construction of the necessary dam has eliminated the Rock Island Rapids, which in the past have proved a great hindrance to navigation. The canal begins at the upper end of the Rock Island Rapids, just below Le Claire and extends downstream, roughly paralleling the Iowa shore, and Smiths Island was used as a portion of the eastern bank. The total length of the improvement is about 3½ miles.

Flood stages during November, 1922.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
MISSISSIPPI DRAINAGE.					
Grand:					
Chillicothe, Mo.	Feet. 18	14	19	Feet. 26.2	18

MEAN LAKE LEVELS DURING NOVEMBER, 1922.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., Dec. 5, 1922.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.[1]			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during November, 1922:	Feet.	Feet.	Feet.	Feet.
Above mean sea level at New York	602.35	579.54	571.41	245.15
Above or below—				
Mean stage of October, 1922	−0.15	−0.43	−0.45	−0.46
Mean stage of November, 1921	+0.15	−0.10	−0.39	+0.30
Average stage for November, last 10 years	−0.25	−0.81	−0.57	−0.54
Highest recorded November stage	−1.16	−3.38	−2.26	−2.67
Lowest recorded November stage	+0.85	+0.36	+0.71	+1.74
Average relation of the November level to—				
October level		−0.20	−0.20	−0.20
December level		+0.20	+0.20	+0.20

[1] Lake St. Clair's level: In November, 574.21 feet.

INFLUENCE OF WEATHER ON CROPS AND FARMING OPERATIONS—NOVEMBER, 1922.

By J. WARREN SMITH, Meteorologist.

November, 1922, was mild for the season in all sections east of the Rocky Mountains, especially from the central Mississippi Valley and central Plains States northward, where the temperature averaged from 4° to 7° above the normal. The first half of the month was cold, however, west of the Rocky Mountains, and the temperature for the month as a whole averaged below normal in that section. The drought conditions that had prevailed between the Mississippi Valley and the Rocky Mountains were relieved or broken early in the month by copious rains, and rainfall about the middle of the month was beneficial in the central Mississippi and the Ohio Valley States. The severe droughty conditions continued, however, throughout the month in most of the middle Atlantic coast section, particularly in much of Pennsylvania, New Jersey, and New York, where streams and wells were reported to be very low and stock water scarce.

Winter grains were greatly benefited by rainfall in the central trans-Mississippi States during the first week in the month, particularly in Kansas, where the best rains in three months occurred. The soil was put in good condition also in Oklahoma, and the seeding of wheat was resumed in that State. Good rains fell in much of the Ohio Valley area during the week ending November 21, which was helpful to winter wheat, particularly in Kentucky. Wheat showed substantial improvement in that area during the latter half of the month and at its close was in mostly good condition to go into the winter. Snowfall the latter part of the month in the far northwestern States was beneficial, although moisture continued insufficient in many sections of that area. Winter cereals needed moisture throughout most of the South.

The mild, dry weather during the first half of the month in the South Atlantic States was favorable for maturing late corn in that section, and conditions were generally favorable for husking and cribbing from the Ohio Valley eastward. Fields were too wet for gathering corn in parts of Iowa and husking made slow progress during much of the month, while there was some damage to corn that had been blown down. The weather was mild and pleasant in much of the interior of the country during the latter part of the month and gathering corn, where not completed, made good progress in most sections.

Conditions were favorable for maturing and harvesting late cotton in the northeastern cotton growing districts but unusually early killing frosts did some damage to this crop in Arizona during the first week of the month. Some top crop matured in Texas. At the close of the month some cotton was still in the fields in the northeastern portion of the belt, but harvest was mostly completed elsewhere.

Truck crops were benefited by rains early in the month in parts of Texas, but moisture continued deficient from the lower Mississippi Valley northeastward to the Middle Atlantic States.

There was improvement in soil conditions in southern Florida, where it had been too wet. It was too warm in Louisiana for the best development of sugar cane, although the lower temperatures the latter part of the month were favorable.

There was sufficient moisture the first half of the month to improve ranges in the West, except in New Mexico, western Texas, and northeastern Arizona, but the continued dry weather in the eastern States was

unfavorable and stock-water shortage continued in many sections. Stock suffered considerably from the cold and snow in some Rocky Mountain sections and Western South Dakota. The unusually mild weather the latter half of the month allowed stock to feed on ranges and harvested fields in the northern Plains States, but much feeding was necessary in northwestern Montana. Ranges improved in central and western Texas, but there was no material change in New Mexico, where shipment to outside ranges continued.

Some damage resulted to apples by freezing in eastern Washington, and some apples were frozen on the trees in Utah during the first week of the month. Strawberries showed some improvement in Florida, but were in generally unsatisfactory condition. It was too warm during most of the month for the best development of citrus in that State, but the cooler weather the latter part was beneficial. Citrus fruits were reported as sizing and coloring nicely in California, and some lemon picking was done the latter part of the month.

CLIMATOLOGICAL TABLES.[1]

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation, by sections, November, 1922.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	57.3	+3.0	Selma	92	1	Valley Head	18	28	1.88	−1.27	Centerville	4.73	Alaga	0.20
Alaska														
Arizona	47.5	−3.9	Parker	90	8	Fort Valley	− 2	4	1.32	+0.32	Ashdale Ranger Sta.	4.00	2 stations	0.20
Arkansas	52.9	+1.4	El Dorado	88	4	Dutton	20	[2] 21	3.89	+0.32	Lincoln	8.82	Texarkana	0.86
California	49.4	−3.4	Indio	91	20	Yreka	8	29	3.33	+0.73	Placerville	9.55	Bagdad	0.00
Colorado	32.6	−2.3	Lamar	78	10	Dillon	−23	13	1.68	+0.81	Savage Basin	4.95	Yuma	T.
Florida	67.8	+2.6	Orlando	92	6	2 stations	26	29	1.60	−1.29	Fort Lauderdale	3.52	2 stations	0.00
Georgia	57.0	+2.3	4 stations	87	[2] 3	Clayton	15	29	0.92	−1.73	Canton	2.32	Millen	0.00
Hawaii	71.5	−0.1	Kaneleau No. 2	91	24	Volcano Observatory	48	22	7.95	−0.11	Eke, Maui	32.00	Olowalu, Maui	0.03
Idaho	32.8	−2.7	Mountain Home	68	1	Obsidian	− 8	30	0.82	−1.35	Prichard	2.40	Glenns Ferry	0.15
Illinois	45.0	+3.1	Mount Carmel	82	1	Clinton	11	25	2.78	+0.38	Quincy	5.88	Palestine	1.60
Indiana	45.0	+2.9	Vevay	86	2	Shoals	12	25	2.25	−0.81	Noblesville	3.57	2 stations	1.19
Iowa	42.2	+7.2	Clarinda	74	4	Decorah	11	25	3.54	+2.03	Iowa City	5.28	Perry	1.96
Kansas	45.6	+1.5	2 stations	80	4	St. Francis	7	14	2.77	+1.57	Herington	7.08	2 stations	T.
Kentucky	48.3	+2.2	Hopkinsville	87	1	Junction City	10	26	1.93	−1.42	Bowling Green	4.55	Shelbyville	0.73
Louisiana	62.9	+4.0	Ten Mile	91	5	3 stations	29	[2] 22	4.28	+0.97	Lakeside	17.96	Burrwood	0.58
Maryland-Delaware	46.3	+1.4	11 stations	75	12	Oakland, Md	14	10	0.66	−1.88	Oakland, Md	1.27	Westernport, Md	0.40
Michigan	39.4	+3.6	Charlotte	70	1	Humboldt	8	25	2.34	−0.10	Calumet	5.78	Durand	0.54
Minnesota	35.9	+6.3	Pine River Dam	76	3	Itasca State Park	2	28	3.32	+2.41	Alexandria	5.41	Gonvick	1.61
Mississippi	58.3	+3.5	2 stations	90	[2] 2	2 stations	25	29	3.78	+0.35	Natchez	7.55	Fulton	1.58
Missouri	47.8	+2.9	Bolivar	87	3	Goodland	15	26	3.82	+1.45	Dean	6.75	Fulton	1.11
Montana	30.8	+1.5	Crow Agency	72	5	Chinook	−18	30	1.84	−0.09	Big Timber	3.26	Chinook	0.03
Nebraska	39.5	+3.0	Weeping Water	78	3	North Loup	3	14	2.55	+1.79	Tekamah	5.02	Alma	0.54
Nevada	36.8	−3.7	Logandale	80	14	Butte Mountain	− 8	23	0.67	+0.15	Lamoille	2.30	Mina	0.00
New England	38.0	+0.9	Turners Falls, Mass.	74	1	2 stations	3	27	1.45	−1.98	Somerset, Vt.	2.87	Block Island, R. I.	0.54
New Jersey	44.3	+1.3	Bridgeton	73	12	Boonton	13	26	0.91	−2.29	Highwood	1.56	Phillipsburg	0.49
New Mexico	40.2	−2.3	3 stations	82	[2] 8	Hermosa	− 2	17	1.08	+0.42	Diener	5.81	2 stations	0.11
New York	39.6	+2.1	3 stations	70	[2] 2	Indian Lake	− 1	27	1.42	−1.37	Gabriels	3.57	Avon	0.24
North Carolina	50.0	+0.8	Sloan	88	6	Banners Elk	4	29	0.63	−1.84	Bryson City	1.82	Rougemont	T.
North Dakota	31.8	+5.2	Granville	65	16	Howard	− 8	30	2.33	+1.75	Pembina	5.33	Lamoine	0.40
Ohio	43.9	+2.8	2 stations	79	[2] 2	Milfordton	10	29	1.56	−1.13	Williamsfield	2.75	Clarington	0.76
Oklahoma	51.4	+0.9	Tahlequah	89	2	Hooker	12	14	3.58	+1.14	Watts	9.69	Beaver	0.31
Oregon	37.9	−3.3	Marshfield	69	21	Lapine	− 4	3	2.09	−2.55	Willow Creek	6.51	Blitzen	0.13
Pennsylvania	42.9	+2.2	2 stations	73	2	Bradys Bend	12	29	1.21	−1.46	Saegerstown	4.52	Neshaminy Falls	0.23
Porto Rico	75.7	−1.0	San German	97	[2] 20	Aibonito	52	[2] 25	3.64	−3.81	Penuelas	7.39	Portala	0.79
South Carolina	54.8	+0.9	2 stations	88	[2] 11	Walhalla	17	29	0.61	−1.67	Cheraw	1.29	Paris Island	0.00
South Dakota	35.1	+2.8	Norris	69	16	Gannvalley	− 2	19	3.00	+2.46	Deadwood	5.50	Orman	1.00
Tennessee	50.0	+1.6	2 stations	82	2	Rugby	11	29	2.39	−0.96	Perryville	5.56	Copperhill	0.57
Texas	58.4	+1.4	Mission	95	4	Romero	11	[2] 13	2.57	+0.18	Liberty	7.14	Riomedina	0.07
Utah	35.7	−2.5	Lehi	75	1	Loa	− 5	8	1.52	+0.47	Silver Lake	5.45	3 stations	T.
Virginia	47.5	+1.3	Onley	87	17	Burkes Garden	5	29	0.57	−1.80	West Point	1.62	Mayhurst	0.07
Washington	37.3	−3.7	Wind River	67	18	2 stations	3	20	1.51	−3.36	Quinault	6.34	Moxee	0.22
West Virginia	43.8	+1.1	4 stations	80	[2] 1	Cheat Bridge	2	29	1.15	−1.40	Pickens	2.49	Moorefield	0.17
Wisconsin	39.1	+5.6	Hillsboro	70	10	Solon Springs	4	25	3.11	+1.32	Weyerhauser	4.96	Brule Island	1.76
Wyoming	28.4	−3.2	Green River	69	8	South Pass City	−15	3	1.24	+0.53	Knowles	3.64	Elk Mountain	T.

[1] For description of tables and cli[illegible] REVIEW, July, 1922, pp. 384-385.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, November, 1922.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Mean wet thermometer.	Mean temperature of the dewpoint.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.						Total.	Departure from normal.	Days with .01, or more.	Total movement.	Prevailing direction.	Maximum velocity.									
																										Miles per hour.	Direction.	Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F*		°*F*	°*F.*		°*F*	°*F.*	°*F.*	°*F.*	°*F.*	*%*	*In.*	*In.*		*Miles.*								*0–10*	*In.*	*In.*
New England.							**40.6**	**+1.4**											**72**	**1.16**	**−2.4**										**6.4**		
Eastport	76	67	85	29.82	29.91	−.10	35.6	−1.1	50	1	41	19	26	30	20	33	29	78	1.93	−2.2	13	8,182	nw.	31	nw.	9	7	5	18	7.0	6.4	0.4
Greenville, Me	1,070	6	....	28.75	29.94	.....	31.2	.....	56	1	37	12	27	25	26	.....	.....	.....	.....	1.97	.....	10	.....	.....	.....	.....	8	1	21	.....	10.4	.....
Portland, Me	103	82	117	29.85	29.98	−.06	39.4	+1.4	59	12	46	20	23	33	21	34	29	69	1.33	−2.5	8	5,903	nw.	32	nw.	9	10	5	15	6.0	1.1	0.0
Concord	288	70	79	29.66	29.98	−.08	38.4	+1.6	64	1	46	11	27	30	36	.....	.....	.....	.....	1.12	−2.3	6	3,978	nw.	23	w.	24	10	5	15	6.2	T.	0.0
Burlington	404	11	48	29.55	30.00	−.05	37.1	+3.4	58	2	43	18	27	31	29	.....	.....	.....	.....	2.14	−0.4	18	7,855	s.	38	s.	14	2	4	24	8.7	2.0	T.
Northfield	876	12	60	29.03	30.00	−.05	35.3	+3.3	59	2	43	8	27	28	39	32	30	84	0.78	−1.9	13	5,031	n.	24	s.	17	3	3	24	8.1	1.5	0.0
Boston	125	115	188	29.84	29.98	−.06	43.8	+1.8	66	12	50	24	27	37	22	38	32	65	0.84	−3.3	8	7,511	w.	35	w.	25	7	11	12	6.3	0.9	0.0
Nantucket	12	14	90	29.96	29.97	−.08	44.5	−0.7	62	15	50	28	26	39	19	41	37	78	0.67	−2.6	8	11,925	nw.	60	ne.	27	11	7	12	5.6	T.	0.0
Block Island	26	11	46	29.96	29.99	−.06	44.0	−0.6	59	15	49	25	23	39	24	41	36	75	0.54	−3.3	5	15,215	nw.	55	nw.	24	10	6	14	5.8	T.	0.0
Providence	160	215	251	29.81	29.99	−.08	42.2	+1.8	63	12	49	21	27	35	22	37	31	66	1.09	−2.8	8	9,357	nw.	55	nw.	24	9	9	12	5.5	0.5	0.0
Hartford	159	122	140	29.84	30.02	−.06	42.5	+3.0	64	2	50	21	27	35	33	37	32	70	0.89	−2.9	8	5,645	nw.	42	nw.	24	7	8	15	6.6	0.5	0.0
New Haven	106	74	153	29.91	30.03	−.04	43.6	+1.6	65	12	51	24	27	36	28	38	32	67	1.48	−2.1	7	6,615	sw.	30	nw.	25	14	7	9	4.8	0.2	0.0
Middle Atlantic States.							**46.3**	**+1.9**											**71**	**0.67**	**−2.2**										**5.5**		
Albany	97	102	115	29.92	30.03	−.05	40.9	+1.6	59	12	48	21	26	34	31	37	32	73	0.90	−1.9	10	4,791	s.	26	nw.	16	6	12	12	6.2	T.	0.0
Binghamton	871	10	84	29.10	30.05	−.04	40.8	+3.2	60	11	48	22	26	34	30	.....	.....	.....	.....	1.04	−1.2	12	4,167	nw.	24	nw.	23	2	9	19	8.0	1.5	T.
New York	314	414	454	29.70	30.05	−.04	45.4	+1.2	65	12	52	27	26	39	20	40	34	67	1.16	−2.3	6	13,209	nw.	64	nw.	8	7	11	12	6.2	1.0	0.0
Harrisburg	374	94	104	29.69	30.10	−.01	45.2	+3.5	66	12	52	30	26	38	26	39	34	67	0.56	−1.8	6	4,508	w.	30	nw.	23	8	9	13	6.1	0.5	0.0
Philadelphia	117	123	190	29.96	30.09	−.01	48.1	+3.2	69	12	55	30	26	41	22	42	34	63	0.43	−2.6	4	6,964	nw.	32	nw.	24	7	11	12	6.0	T.	0.0
Reading	325	81	98	29.72	30.08	.....	45.8	.....	65	12	53	27	26	39	28	40	35	71	0.55	−2.6	5	3,582	nw.	24	n.	25	7	13	10	5.6	T.	0.0
Scranton	805	111	119	29.19	30.08	−.01	42.4	+3.3	62	7	49	25	26	36	24	38	33	75	0.76	−1.5	9	4,990	sw.	33	sw.	24	4	6	20	7.5	0.2	0.0
Atlantic City	52	37	172	30.02	30.08	−.02	47.1	+1.5	70	12	54	26	26	40	21	42	38	74	0.58	−2.6	6	11,336	nw.	45	nw.	24	13	11	6	4.4	T.	0.0
Cape May	18	13	49	30.09	30.11	+.01	48.2	+0.8	70	12	55	30	26	42	23	43	39	76	0.71	−2.5	4	6,848	nw.	31	nw.	24	12	4	14	5.4	0.0	0.0
Sandy Hook	22	10	55	30.02	30.05	.....	45.6	.....	63	12	51	30	26	41	19	41	36	72	1.10	.....	7	11,898	sw.	51	nw.	24	7	14	9	5.5	0.3	0.0
Trenton	190	159	183	29.86	30.06	.....	45.0	.....	66	12	53	27	28	37	29	39	33	69	0.62	−2.8	5	7,740	nw.	46	nw.	24	8	11	11	5.7	T.	0.0
Baltimore	123	100	113	29.97	30.10	−.01	49.0	+2.7	72	12	57	29	29	41	27	42	36	68	0.44	−2.5	4	3,687	w.	20	w.	24	13	6	11	5.2	T.	0.0
Washington	112	62	85	29.98	30.11	−.01	47.9	+2.7	74	12	57	28	30	39	32	41	35	68	0.55	−2.2	4	4,331	nw.	33	nw.	20	13	5	12	5.2	T.	0.0
Lynchburg	681	153	188	29.39	30.14	+.01	48.4	+1.2	73	19	60	24	22	37	38	41	35	67	0.19	−2.6	3	5,376	w.	34	nw.	20	16	8	6	4.0	T.	0.0
Norfolk	91	170	205	30.03	30.13	+.02	51.8	+0.6	74	15	59	27	26	44	26	45	40	70	0.44	−2.3	3	9,139	n.	48	nw.	15	17	7	6	3.4	T.	0.0
Richmond	144	11	52	29.98	30.14	+.02	49.0	+0.2	73	19	60	25	29	38	32	42	36	70	0.86	−1.5	3	5,286	sw.	30	sw.	15	11	11	8	4.8	0.0	0.0
Wytheville	2,304	49	55	27.75	30.18	+.05	43.6	+0.6	67	12	53	20	29	34	36	37	32	72	0.86	−2.2	6	5,083	w.	29	sw.	23	14	7	9	4.6	0.5	0.0
South Atlantic States.							**55.8**	**+1.6**											**73**	**0.44**	**−2.3**										**3.9**		
Asheville	2,255	70	84	27.80	30.20	+.06	46.5	+1.4	72	6	57	17	29	36	37	39	34	70	0.26	−2.0	3	6,457	nw.	34	nw.	24	18	6	6	3.5	0.9	0.0
Charlotte	779	55	62	29.32	30.17	+.04	51.6	+1.0	74	6	62	24	29	42	29	44	38	66	0.92	−1.9	5	3,261	sw.	19	nw.	28	16	8	6	3.4	0.5	0.0
Hatteras	11	12	11	30.10	30.11	.00	55.8	−0.5	74	14	61	36	26	51	19	51	47	77	0.79	−3.9	7	10,118	n.	44	nw.	15	19	5	6	3.5	0.0	0.0
Manteo	12	5	42	.....	.....	.....	52.8	.....	79	15	65	28	28	40	32	.....	.....	.....	.....	0.04	.....	1	.....	ne.	.....	.....	24	2	4	.....	0.0	0.0
Raleigh	376	103	110	29.74	30.15	+.02	51.6	+1.4	75	15	61	25	26	42	30	44	39	70	0.36	−2.0	3	5,493	n.	33	nw.	15	17	6	7	3.6	0.0	0.0
Wilmington	78	81	91	30.08	30.16	+.04	54.8	+0.7	80	7	65	29	29	45	28	48	44	76	0.46	−2.0	5	4,287	n.	22	n.	28	19	7	4	2.9	0.2	0.0
Charleston	48	11	92	30.10	30.16	+.04	60.1	+2.0	82	7	68	34	29	52	26	53	50	76	0.10	−2.8	4	7,238	ne.	37	n.	28	11	15	4	4.3	0.0	0.0
Columbia, S. C	351	41	57	29.79	30.18	+.06	55.5	+1.7	78	15	66	27	29	45	32	47	41	68	0.44	−1.8	3	3,923	ne.	20	n.	28	18	7	5	3.7	T.	0.0
Due West	711	10	55	29.41	30.20	.....	52.8	.....	78	3	63	23	29	42	32	.....	.....	.....	.....	0.52	.....	4	5,135	sw.	24	n.	28	14	8	8	4.5	0.0	0.0
Greenville, S. C	1,039	113	122	29.05	30.16	.....	52.4	.....	76	3	62	26	29	43	28	45	40	69	0.48	.....	6	5,385	ne.	26	ne.	28	19	6	5	3.2	T.	0.0
Augusta	180	62	77	29.96	30.16	+.03	56.8	+2.3	80	15	67	28	29	47	37	50	47	78	0.49	−2.4	5	3,110	nw.	21	n.	28	13	12	5	4.6	T.	0.0
Savannah	65	150	194	30.08	30.15	+.03	60.8	+3.3	82	3	69	33	29	52	26	53	49	76	0.01	−2.4	1	7,975	ne.	48	nw.	28	14	11	5	4.1	0.0	0.0
Jacksonville	43	209	245	30.08	30.13	+.03	64.8	+2.6	83	15	72	37	27	58	30	58	54	77	0.58	−1.6	1	8,475	n.	37	n.	28	12	11	7	5.0	0.0	0.0
Florida Peninsula.							**72.8**	**+1.8**											**76**	**3.27**	**+1.1**										**5.1**		
Key West	22	10	64	30.02	30.04	+.02	75.6	+1.3	85	26	80	60	29	71	13	70	68	80	3.36	+1.0	11	8,113	e.	44	w.	24	11	12	7	4.8	0.0	0.0
Miami	25	71	79	30.04	30.07	.....	73.1	+1.1	83	1	78	52	29	68	20	67	64	75	5.44	+2.9	16	6,608	e.	27	ne.	11	9	11	10	5.7	0.0	0.0
Sand Key	23	39	72	30.02	30.05	+.03	75.2	.....	82	22	78	62	29	72	10	70	67	74	3.87	.....	12	12,908	e.	42	nw.	27	10	16	4	4.9	0.0	0.0
Tampa	35	79	92	30.06	30.10	+.02	69.8	+3.0	84	4	78	43	29	62	24	62	59	76	1.01	−0.7	4	4,707	e.	24	n.	28	9	16	5	5.0	0.0	0.0
East Gulf States.							**59.2**	**+3.2**											**75**	**2.08**	**−1.4**										**5.0**		
Atlanta	1,174	190	216	28.92	30.17	+.04	52.9	+0.8	75	3	62	28	29	44	24	48	45	80	1.42	−2.0	7	8,702	nw.	40	nw.	28	15	4	11	4.4	0.0	0.0
Macon	370	78	87	29.78	30.18	+.05	56.6	+3.3	79	15	67	27	29	46	38	49	44	72	0.54	−2.6	5	4,081	e.	26	nw.	27	9	12	9	5.3	0.1	0.0
Thomasville	273	49	58	29.84	30.14	+.02	62.2	+3.7	83	2	72	32	29	52	30	54	50	76	1.10	−1.5	3	3,024	ne.	18	sw.	27	8	15	7	5.2	0.0	0.0
Apalachicola	36	42	49	30.09	30.13	.....	64.5	.....	80	3	71	39	29	58	26	59	56	79	0.72	.....	2	6,219	ne.	28	n.	19	13	10	7	4.4	0.0	0.0
Pensacola	56	149	185	30.07	30.13	+.02	63.4	+3.2	79	3	70	38	26	57	26	58	54	76	0.72	−3.0	5	9,444	ne.	31	w.	27	7	11	12	5.8	0.0	0.0
Anniston	741	9	57	29.38	30.20	+.08	53.8	+1.9	78	3	65	22	29	43	39	.....	.....	.....	.....	1.83	−1.6	6	4,175	se.	28	nw.	27	14	9	7	4.4	T.	0.0
Birmingham	700	11	48	29.42	30.20	+.08	56.4	+2.3	80	1	66	30	25	46	29	48	42	68	2.59	−0.8	8	4,960	n.	30	nw.	27	15	8	7	3.9	0.0	0.0
Mobile	57	125	161	30.08	30.14	+.03	62.8	+3.8	84	2	71	38	26	55	28	57	54	79	3.98	+0.2	7	6,975	n.	28	n.	28	9	11	10	5.8	0.0	0.0
Montgomery	223	100	112	29.92	30.18	+.06	59.2	+3.4	82	6	69	32	29	49	37	51	46	70	1.27	−1.9	5	4,658	se.	26	nw.	27	13	8	9	4.7	T.	0.0
Corinth	469	6	....	.....	.....	.....	54.1	.....	82	12	66	26	29	42	37	.....	.....	.....	.....	4.12	.....	6	.....	se.	.....	.....	.....	7	20	3	.....	0.0	0.0
Meridian	375	85	93	29.76	30.16	+.04	58.4	+5.2	81	3	68	34	29	48	30	51	47	74	2.54	−1.6	9	3,654	n.	23	sw.	27	12	9	9	4.9	T.	0.0
Vicksburg	247	65	73	29.88	30.17	+.05	59.4	+2.8	84	4	69	35	21	50	28	52	47	73	3.55	−0.6	8	4,633	se.	22	w.	27	10	7	13	5.4	0.0	0.0
New Orleans	53	76	84	30.06	30.12	+.02	66.5	+4.9	85	6	74	44	26	60	25	59	55	73	3.38	−0.4	6	5,039	ne.	23	w.	27	8	12	10	5.5	0.0	0.0
West Gulf States.							**59.0**	**+2.6**											**76**	**2.82**	**−0.3**										**6.1**		
Shreveport	249	77	93	29.88	30.16	+.05	58.3	+3.0	85	3	68	36	21	48	29	51	46	75	2.01	−2.1	8	4,546	n.	22	se.	30	16	5	9	4.6	0.0	0.0
Bentonville	1,303	11	44	.....	.....	.....	50.1	+3.4	79	3	61	26	20	39	35	.....	.....	.....	.....	6.75	.....	7	.....	.....	.....	.....	.....	17	7	6	.....	0.0	0.0
Fort Smith	457	79	94	29.65	30.14	+.03	53.4	+3.5	81	4	63	32	26	44	32	46	40	67	5.28	+2.0	7	5,641	e.	48	w.	12	12	11	7	4.8	0.0	0.0
Little Rock	357	136	144	29.76	30.15	+.03	54.3	+2.8	81	5	64	30	26	45	31	47	41	70	2.07	−2.5	9	5,481	n.	41	nw.	27	13	7	10	4.8	0.0	0.0
Brownsville	57	4	26	29.99	30.05	.....	67.6	.....	86	6	75	49	25	60	31	62	60	87	3.67	.....	9	6,001	nw.	32	s.	30	7	10	13	6.3	0.0	0.0
Corpus Christi	20	11	73	30.06	30.08	+.01	66.2	+2.8	84	6	72	45	26	60	35	62	59	82	3.47	+1.1	10	8,932	n.	42	nw.	6	4	8	18	7.4	0.0	0.0
Dallas	512	109	117	29.58	30.13	.....	57.4	.....	82	3	67	37	20	48	30	.....	.....	.....	.....	2.94	.....	10	5,926	nw.	30	nw.	12	7	9	14	6.2	0.0	0.0
Fort Worth	670	106	114	29.40	30.12	+.02	57.5	+2.4	82	3	66	38	13	49	30	50	44	68	2.57	+1.0	6	6,478	se.	31	se.	4	7	13	10	5.4	0.0	0.0
Galveston	54	106	114	30.05	30.11	+.02	65.6	+2.3	79	6	71	48	26	60	25	61	58	82	2.54	−1.5	5	8,198	n.	26	n.	21	5	12	13	6.3	0.0	0.0
Groesbeck	461	11	56	29.62	30.10	.....	58.8	.....	85	4	68	36	26	49	32	.....	.....	.....	.....	2.02	.....	8	7,153	n.	34	s.	30	6	10	14	6.3	0.0	0.0
Houston	138	111	121	29.94	30.10	.....	64.2	+2.9	84	4	72	42	26	56	32	.....	.....	.....	.....	3.82	.....	5	5,884	n.	26	se.	10	5	7	18	6.7	0.0	0.0
Palestine	510	64	72	29.59	30.13	+.02	58.2	+1.3	82	3	67	37	26	49	30	51	47	73	4.37	+0.7	10	5,200	ne.	28	s.	30	8	10	12	6.1	0.0	0.0
Port Arthur	34	58	66	30.06	30.10	.....	63.8	.....	81	6	71	41	26	57	30	58	55	79	1.78	.....	5	6,664	ne.	24	ne.	20	8	4	18	6.6	0.0	0.0
San Antonio	701	119	132	29.36	30.09	+.01	61.9	+2.7	83	3	70	41	13	54	33	55	51	74	0.98	−0.8	12	5,966	n.	28	n.	12	6	7	17	7.0	0.0	0.0
Taylor	582	55	63	29.51	30.13	+.05	59.6	+1.9	83	3	68	38	13	51	36	.....	.....	.....	.....	2.10	−0.5	7	5,868	n.	26	se.	24	5	8	17	7.0	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, November, 1922*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Mean wet thermometer.	Mean temperature of the dewpoint.	Mean relative humidity.	Precipitation.			Wind.				Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with .01, or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
Ohio Valley and Tennessee.	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	° *F.*	° *F.*	° *F*		° *F*	° *F.*		° *F*	° *F.*	° *F.*	° *F.*	° *F.*	%	*In.*	*In.*		*Miles.*							*0–10*	*In.*	*In.*
							47.6	+2.7											71	1.72	−1.7									5.5		
Chattanooga	762	189	213	29.38	30.20	+.06	52.2	+1.8	79	3	62	26	29	43	30	44	37	63	1.24	−2.3	9	5,701	nw.	28	nw.	28	14	9	7	4.1	T.	0.0
Knoxville	996	102	111	29.12	30.20	+.07	49.1	+2.0	72	1	59	21	26	39	31	43	38	72	1.80	−1.8	6	3,657	ne.	24	sw.	27	13	6	11	4.9	1.8	0.0
Memphis	399	76	97	29.77	30.21	+.09	54.8	+3.1	80	4	63	32	25	46	26	47	41	66	3.50	−1.1	6	5,707	n.	40	nw.	27	11	11	8	4.1	0.0	0.0
Nashville	546	168	191	29.60	30.20	+.08	51.3	+2.3	79	1	61	24	26	42	32	44	38	67	1.80	−2.0	6	7,010	s.	43	s.	1	15	8	7	4.0	0.0	0.0
Lexington	989	193	230	29.09	30.18	+.06	47.2	+2.5	76	1	55	20	25	39	27				0.88	−2.6	6	10,204	sw.	36	se.	1	14	7	9	4.4	0.6	0.0
Louisville	525	219	255	29.59	30.18	+.06	48.4	+1.7	75	1	56	23	25	41	25	42	36	66	1.83	−2.4	5	8,379	s.	34	sw.	23	16	8	6	4.3	0.1	0.0
Evansville	431	139	175	29.70	30.18	+.06	49.3	+4.0	78	1	58	24	25	41	26	43	38	71	1.64	−2.5	8	8,054	sw.	37	sw.	1	11	12	7	4.7	3.1	0.0
Indianapolis	822	194	230	29.24	30.15	+.05	45.4	+3.8	69	12	52	22	25	38	24	40	36	73	2.32	−1.2	10	8,925	s.	39	sw.	23	8	8	14	6.0	0.2	0.0
Royal Center	736	11	55	29.30	30.12	.....	42.6	.....	68	5	50	21	25	38	26	.....	.....	.....	2.15	.....	12	8,000	w.	34	sw.	1	4	6	20	7.6	0.1	0.0
Terre Haute	575	96	129	29.51	30.14	.....	46.0	.....	71	5	54	20	25	38	25	41	37	76	1.22	.....	9	7,217	s.	28	s.	30	9	12	9	5.6	T.	0.0
Cincinnati	628	11	51	29.47	30.16	+.04	46.4	+3.9	73	2	55	22	26	38	28	.....	36	72	1.88	−1.3	7	5,576	sw.	27	sw.	2	10	10	10	5.3	0.7	0.0
Columbus	824	179	222	29.25	30.14	+.03	44.4	+2.5	69	2	52	20	25	37	26	39	35	74	1.57	−1.5	10	8,225	s.	37	nw.	24	6	4	17	6.9	1.0	0.0
Dayton	899	181	216	29.16	30.14	.....	45.3	+3.2	71	1	53	23	26	38	26	40	35	73	1.79	−1.1	8	8,170	sw.	32	w.	23	11	8	11	5.2	1.3	0.0
Elkins	1,947	59	67	28.07	30.18	+.06	41.8	+2.2	74	1	53	17	29	31	51	36	33	81	1.55	−1.3	11	3,840	w.	30	w.	24	5	8	17	7.2	4.6	T.
Parkersburg	638	77	84	29.50	30.17	+.05	46.0	+2.8	75	2	55	20	29	38	32	40	35	71	0.97	−1.9	7	4,062	se.	29	nw.	23	9	5	16	6.3	0.4	0.0
Pittsburgh	842	353	410	29.21	30.13	+.03	45.3	+2.1	69	1	52	23	29	39	33	40	35	72	1.31	−1.2	8	8,730	sw.	47	nw.	23	5	3	22	7.8	1.0	0.0
Lower Lake Region.							42.2	+2.8											75	1.37	−1.6									7.8		
Buffalo	767	247	280	29.20	30.05	.00	42.0	+2.6	64	1	48	22	26	36	32	40	37	85	1.08	−2.3	15	13,370	nw.	62	sw.	23	2	6	22	8.0	3.1	0.0
Canton	448	10	61	29.51	30.00	.....	37.0	+3.1	61	2	44	16	29	30	33	.....	.....	.....	1.66	−1.8	15	7,242	w.	45	sw.	17	2	5	23	8.2	1.7	0.0
Oswego	335	76	91	.....	30.03	−.02	41.7	+2.8	63	11	47	23	25	36	24	.....	.....	.....	1.27	−2.1	12	8,002	nw.	34	nw.	24	2	1	27	.....	1.8	0.0
Rochester	523	86	102	29.47	30.05	.00	41.9	+3.2	64	11	48	21	26	36	28	37	32	71	1.12	−1.6	17	6,473	sw.	36	sw.	17	2	5	23	8.4	1.8	0.0
Syracuse	597	97	113	29.40	30.05	−.01	41.0	+2.3	62	11	47	21	26	35	23	.....	.....	.....	1.23	−1.5	16	7,867	w.	45	nw.	24	1	5	24	8.5	3.5	0.0
Erie	714	130	166	29.28	30.07	+.01	43.7	+2.3	65	2	49	25	29	38	25	39	33	69	2.99	−0.6	15	11,603	nw.	48	nw.	23	2	7	21	8.0	4.3	0.0
Cleveland	762	190	201	29.26	30.10	+.03	44.2	+3.3	67	6	50	21	29	38	28	39	34	70	1.37	−1.4	10	10,892	sw.	48	nw.	23	3	9	18	8.0	2.6	0.0
Sandusky	629	62	103	29.40	30.10	+.02	44.1	+3.3	67	6	50	24	29	38	25	.....	.....	.....	1.27	−1.5	10	10,640	sw.	43	nw.	23	3	9	18	7.7	1.8	0.0
Toledo	628	208	243	29.41	30.11	+.04	43.4	+3.0	65	6	50	24	25	37	23	39	35	75	0.96	−1.7	8	11,409	sw.	44	sw.	30	7	8	15	6.7	0.3	0.0
Fort Wayne	856	113	124	29.18	30.12	.....	42.2	+1.6	69	5	49	23	26	36	27	39	36	81	1.72	.....	13	7,766	sw.	32	sw.	30	5	8	17	7.2	0.6	0.0
Detroit	730	218	258	29.28	30.09	+.03	42.7	+3.4	63	6	48	24	28	37	20	39	35	77	0.78	−1.8	11	9,542	sw.	37	sw.	29	5	5	20	7.6	1.4	0.0
Upper Lake Region.							39.5	+4.8											81	2.45	0.0									8.4		
Alpena	609	13	92	29.35	30.02	+.01	38.7	+4.3	61	17	44	21	28	33	26	36	33	82	2.61	0.0	16	8,879	sw.	39	sw.	17	1	4	25	8.8	1.2	0.0
Escanaba	612	54	60	29.34	30.02	−.01	37.8	+6.1	61	17	43	19	25	33	22	35	32	82	2.02	−0.2	13	7,412	sw.	36	ne.	19	3	3	24	8.4	1.7	0.0
Grand Haven	632	54	89	29.36	30.05	+.01	43.0	+5.0	62	5	48	26	24	38	22	40	37	80	3.63	+1.1	18	11,055	sw.	39	s.	30	0	5	25	9.2	3.3	0.0
Grand Rapids	707	70	87	29.29	30.07	+.02	42.4	+4.3	62	5	48	25	24	37	24	38	35	76	2.39	−0.1	16	5,140	s.	27	w.	23	1	3	26	9.0	2.0	0.0
Houghton	684	62	99	29.27	30.01	−.01	36.2	+4.7	52	5	41	19	25	32	23	.....	.....	.....	2.10	−0.7	20	7,198	e.	46	sw.	30	0	4	26	9.3	6.0	0.6
Lansing	878	11	62	29.10	30.07	.....	40.7	+3.9	62	5	47	21	28	34	25	37	34	83	1.79	−0.6	16	5,273	sw.	23	nw.	23	2	6	22	8.1	3.5	0.0
Ludington	637	60	66	29.33	30.04	.....	41.8	.....	62	5	46	26	24	37	18	39	35	79	2.02	.....	20	10,396	sw.	39	s.	30	2	3	25	8.4	1.8	0.0
Marquette	734	77	111	29.22	30.03	+.01	37.6	+5.7	61	17	42	21	25	33	25	34	31	80	2.84	0.0	20	7,974	nw.	45	s.	30	1	2	27	9.1	5.0	0.3
Port Huron	638	70	120	29.35	30.06	+.01	40.9	+3.4	64	6	47	20	28	35	24	37	34	80	0.74	−1.9	10	9,220	sw.	42	nw.	23	1	12	17	7.2	2.4	0.0
Saginaw	641	69	77	29.35	30.06	.....	40.4	.....	61	6	46	17	28	34	21	37	35	84	1.66	−0.6	13	6,923	sw.	32	sw.	30	2	6	22	8.5	2.5	0.0
Sault Sainte Marie	614	11	52	29.31	30.02	+.01	35.4	+4.7	54	30	41	12	28	30	24	33	31	86	3.55	+0.6	17	6,435	nw.	38	nw.	23	2	5	23	8.5	6.8	T
Chicago	823	140	310	29.18	30.09	+.02	44.6	+3.4	66	5	50	21	25	39	19	40	36	73	2.66	+0.2	12	9,709	w.	44	sw.	30	5	5	20	7.5	0.2	0.0
Green Bay	617	109	144	29.34	30.01	−.03	39.8	+7.3	59	11	45	22	25	35	20	37	33	78	2.25	+0.3	12	9,273	s.	46	s.	30	1	6	23	8.5	T.	0.0
Milwaukee	681	125	139	29.30	30.05	.00	42.0	+5.9	62	11	47	22	25	37	24	39	36	80	2.47	+0.5	11	8,524	w.	40	sw.	30	5	5	20	7.7	T.	0.0
Duluth	1,133	11	47	28.76	30.00	−.04	34.2	+4.2	55	17	39	10	25	29	23	33	31	90	3.57	+2.0	14	9,596	ne.	68	sw.	30	4	1	25	8.2	5.6	T
North Dakota.							32.7	+6.4											85	2.02	+1.3									8.0		
Moorhead	940	50	58	28.98	30.02	−.05	34.2	+7.1	53	4	40	9	30	29	24	33	31	89	2.83	+1.8	14	6,046	n.	30	se.	5	2	3	25	8.7	3.9	2.2
Bismarck	1,674	8	57	28.26	30.10	+.03	33.2	+4.7	52	5	40	11	30	27	28	31	28	85	1.51	+0.8	8	6,713	nw.	42	nw.	18	5	6	19	7.5	5.7	T.
Devils Lake	1,482	11	44	28.42	30.04	−.02	31.6	+9.0	52	16	38	4	30	25	27	29	27	88	2.38	+1.7	11	6,963	nw.	30	e.	5	3	4	23	8.2	3.5	2.2
Ellendale	1,457	10	56	.....	30.05	.....	32.8	.....	59	2	39	11	30	26	29	.....	.....	.....	2.73	.....	11	10,429	nw.	48	nw.	18	3	8	19	.....	12.4	5.5
Grand Forks	835	12	89	.....	.....	.....	33.2	.....	56	1	39	4	30	27	31	.....	.....	.....	3.30	.....	10	.....	.....	.....	.....	.....	4	1	25	8.5	0.7	0.0
Williston	1,878	41	48	28.06	30.00	+.03	31.9	+4.7	53	16	39	1	30	25	32	29	25	79	1.37	+0.8	8	5,667	nw.	36	nw.	18	5	5	20	7.7	8.0	1.5
Upper Mississippi Valley.							43.9	+5.5											77	3.17	+1.2									6.6		
Minneapolis	918	102	208	28.99	29.99	.....	39.6	.....	62	30	45	17	25	34	38	.....	.....	.....	3.57	+2.4	13	9,217	n.	46	sw.	30	3	4	23	8.5	0.8	0.0
St. Paul	837	236	261	29.09	30.01	−.05	38.8	+4.7	62	30	44	17	25	33	39	.....	.....	.....	3.70	+2.4	13	9,778	sw.	58	sw.	30	3	3	24	8.5	1.5	0.0
La Crosse	714	11	48	29.24	30.03	−.04	41.6	+6.4	63	10	48	15	25	36	29	.....	.....	.....	3.50	+2.0	11	4,333	s.	27	sw.	30	3	6	21	8.1	0.3	0.0
Madison	974	70	78	29.00	30.07	+.01	41.0	+6.8	62	5	47	17	25	35	24	37	34	82	3.14	+1.3	11	8,309	sw.	32	sw.	30	3	6	21	7.8	T.	0.0
Wausau	1,247	4	.....	28.67	30.03	.....	37.2	.....	57	3	42	18	25	32	23	.....	.....	.....	2.10	.....	14	.....	se.	.....	.....	.....	4	1	25	8.5	0.7	0.0
Charles City	1,015	10	49	28.95	30.05	−.03	40.0	+7.0	64	30	46	15	25	34	34	37	34	84	3.14	+1.8	10	6,344	sw.	34	sw.	30	4	9	17	7.3	0.8	0.0
Davenport	606	71	79	29.42	30.09	+.01	43.9	+6.4	65	5	50	19	25	37	26	40	36	77	3.12	+1.4	9	6,095	sw.	29	ne.	12	6	8	16	6.6	1.5	0.0
Des Moines	861	84	97	29.13	30.06	−.02	44.0	+7.2	69	30	52	19	25	37	35	40	36	78	2.54	+1.1	9	6,598	sw.	52	sw.	30	14	6	10	5.0	T.	0.0
Dubuque	698	81	96	29.32	30.08	+.01	42.7	+5.7	64	2	49	19	25	37	27	38	34	76	4.41	+2.6	10	5,273	nw.	24	nw.	23	4	8	18	7.2	1.2	0.0
Keokuk	614	64	78	29.42	30.11	+.02	45.4	+6.0	65	3	53	22	25	38	25	40	35	73	3.38	+1.5	11	6,372	sw.	36	s.	5	9	13	8	5.3	0.0	0.0
Cairo	358	87	93	29.77	30.16	+.04	50.7	+3.4	75	2	59	27	26	42	27	44	39	70	1.98	−2.0	9	6,118	s.	37	nw.	27	11	9	10	5.1	T.	0.0
Peoria	609	11	45	29.44	30.11	+.02	43.2	+5.7	68	5	50	17	25	36	25	39	37	84	3.67	+1.0	11	5,393	s.	24	w.	7	10	9	11	5.7	2.5	0.0
Springfield, Ill	644	10	91	29.42	30.11	+.01	45.2	+3.0	71	5	52	21	25	38	22	40	37	80	2.53	−0.1	10	6,599	w.	28	s.	5	10	8	12	5.7	1.0	0.0
Hannibal	534	74	109	29.52	30.10	+.01	46.0	+5.5	68	3	53	24	25	39	24	.....	.....	.....	3.36	+1.4	10	6,876	sw.	31	s.	1	12	10	8	4.9	0.0	0.0
St. Louis	567	265	303	29.51	30.13	+.03	48.8	+3.7	73	5	56	25	25	42	24	43	37	69	2.36	−0.5	10	9,784	s.	44	s.	5	11	10	9	4.8	T.	0.0
Missouri Valley.							43.0	+4.9											75	3.19	+2.0									4.9		
Columbia, Mo	781	11	84	29.26	30.10	+.01	47.4	+5.0	73	3	56	22	25	38	27	.....	.....	.....	2.37	+0.1	8	6,519	sw.	34	nw.	27	14	8	8	4.3	0.0	0.0
Kansas City	963	161	181	29.05	30.11	+.02	47.8	+6.3	73	4	56	25	25	40	23	42	36	69	3.17	+1.3	10	8,426	sw.	48	nw.	27	18	6	6	3.6	0.0	0.0
St. Joseph	967	11	49	29.03	30.08	.....	46.3	.....	74	3	54	24	25	38	29	40	35	71	4.99	.....	10	6,934	nw.	37	nw.	27	17	6	7	3.8	0.0	0.0
Springfield, Mo	1,324	98	104	28.72	30.14	+.04	48.1	+3.7	75	3	57	26	20	39	28	41	35	67	4.14	+1.5	6	7,874	se.	38	sw.	1	14	11	5	4.0	0.0	0.0
Iola	984	11	50	29.05	30.12	+.03	47.8	+4.8	78	4	59	25	28	37	32	.....	.....	.....	3.01	+1.6	6	5,335	se.	32	w.	12	14	7	9	4.6	0.0	0.0
Topeka	987	92	107	.....	.....	.....	47.0	+5.3	76	4	57	25	25	37	31	.....	.....	.....	4.83	+3.6	8	7,980	w.	46	n.	27	17	6	7	3.7	0.0	0.0
Drexel	1,299	10	54	28.64	30.04	.....	41.6	.....	70	3	50	20	25	33	33	.....	.....	.....	3.57	.....	7	9,665	sw.	52	sw.	30	13	5	12	5.0	0.0	0.0
Lincoln	1,189	11	84	28.78	30.08	.00	43.6	+5.6	72	3	53	21	25	34	34	38	34	73	2.62	+1.8	8	8,713	s.	40	sw.	30	13	8	9	4.2	0.0	0.0
Omaha	1,105	115	122	28.87	30.08	.00	44.2	+6.5	72	3	52	25	24	36	32	39	35	75	2.55	+1.5	10	6,464	nw.	43	nw.	27	15	5	10	4.6	0.6	0.0
Valentine	2,598	47	54	27.31	30.08	.00	36.9	+3.2	63	4	47	12	14	27	34	33	28	75	2.74	+2.0	6	7,593	w.	46	nw.	5	11	10	9	4.9	5.9	T.
Sioux City	1,135	94	164	28.83	30.07	−.01	41.2	+6.9	64	3	48	21	24	34	31	37	33	76	4.41	+3.4	8	10,930	nw.	56	sw.	30	9	8	13	5.8	T.	0.0
Huron	1,306	59	74	28.64	30.08	.00	35.2	+3.7	61	4	42	12	15	28	26	33	31	86	2.72	+2.1	9	7,651	nw.	42	w.	5	9	1	20	6.8	11.5	T.
Pierre	1,572	70	75	28.37	30.08	.00	36.7	+3.1	64	28	44	17	20	29	32	33	30	81	3.16	+2.7	8	7,262	nw.	52	nw.	6	8	5	17	6.4	13.9	3.3
Yankton	1,233	49	57	28.70	30.04	−.04	40.4	+5.0	68	10	48	21	14	33	32	.....	.....	.....	2.57	+1.8	8	7,415	w.	41	sw.	30	7	9	14	6.3	5.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, November, 1922*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.											Mean wet thermometer.	Mean temperature of the dewpoint.	Mean relative humidity.	Precipitation.			Wind.				Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with .01, or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	°F.		%	*In.*	*In.*		*Miles.*							*0–10*	*In.*	*In.*
Northern Slope.							**31.0**	**−1.3**												**73**	**1.51**	**+0.7**									**5.4**		
Billings	3,140	5					31.0		65	26	40	−4	13	22	32						1.47		7		nw.				20	3	7		14.2	0.0
Havre	2,505	11	44	27.44	30.16	+.13	30.8	−0.4	63	26	43	−5	30	19	39	26	22	79			0.54	−0.2	7	4,615	sw.	34	sw.	15	11	9	10	4.9	4.8	3.2
Helena	4,110	87	112	25.89	30.22	+.15	29.5	−3.2	60	26	38	8	13	21	29	25	21	75			1.04	+0.3	7	4,427	sw.	42	sw.	18	10	6	14	5.8	13.0	2.5
Kalispell	2,973	48	56	27.07	30.22	+.15	30.0	−2.0	49	8	37	16	30	23	25	27	24	78			1.06	−0.8	6	2,646	nw.	36	sw.	17	9	4	17	6.6	5.3	3.3
Miles City	2,371	48	55	27.56	30.18	+.11	35.3	+4.4	62	26	45	10	30	26	34	30	24	68			0.44	−0.2	7	4,358	sw.	36	nw.	18	11	6	13	5.6	0.5	0.4
Rapid City	3,259	50	58	26.64	30.14	+.06	35.7	+2.1	63	28	44	14	30	27	33	31	25	68			3.24	+2.8	9	6,081	nw.	48	nw.	5	10	7	13	5.6	10.1	0.6
Cheyenne	6,088	84	101	24.00	30.14	+.07	31.4	−3.5	55	16	41	10	13	22	34	27	22	70			2.40	+2.0	7	9,103	nw.	62	w.	18	13	7	10	4.9	22.5	0.5
Lander	5,372	60	68	24.70	30.27	+.17	21.3	−7.4	50	18	30	−3	24	12	34	18	14	74			1.57	+1.0	6	1,882	w.	20	nw.	18	11	5	14	5.8	13.7	2.0
Sheridan	3,790	10	47	26.17	30.18		32.8		61	26	43	3	12	23	34	28	24	76			1.16		9	3,411	nw.	40	nw.	5	9	10	11	5.3	6.6	T.
Yellowstone	6,200	11	48	23.92	30.25	+.14	25.8	−3.5	49	27	36	−1	13	16	31	21	17	74			0.96	−0.5	12	4,336	s.	31	n.	18	10	9	11	5.2	11.9	4.4
North Platte	2,821	11	51	27.13	30.13	+.05	38.8	+2.2	65	3	50	11	13	27	39	33	28	74			2.35	+2.0	5	5,807	w.	39	nw.	5	12	6	12	4.8	5.5	0.0
Middle Slope.							**44.0**	**+2.1**												**69**	**2.32**	**+1.4**									**4.0**		
Denver	5,292	106	113	24.74	30.12	+.06	37.2	−2.6	62	26	47	2	13	27	31	31	24	65			1.95	+1.4	5	4,980	s.	40	nw.	4	10	12	8	3.8	15.4	0.0
Pueblo	4,685	80	86	25.32	30.10	+.05	37.6	−1.7	68	10	50	5	13	25	42	31	24	66			1.26	+0.9	7	4,394	nw.	44	nw.	4	9	12	9	5.6	12.2	0.0
Concordia	1,392	50	58	28.60	30.10	+.02	44.8	+4.9	72	4	55	22	20	35	33	39	34	72			2.05	+1.1	6	7,002	s.	36	nw.	1	15	7	8	4.5	T	0.0
Dodge City	2,509	11	51	27.48	30.13	+.06	45.5	+5.0	75	2	58	18	14	33	39	38	32	68			0.95	+0.4	6	8,867	nw.	49	sw.	4	17	9	4	3.3	T.	0.0
Wichita	1,358	139	158	28.64	30.10	+.02	47.6	+3.8	72	2	56	28	14	39	31	41	36	69			5.35	+4.2	7	9,989	s.	53	w.	4	16	7	7	3.7	0.0	0.0
Altus	1,410	5					53.4		77	3	66	26	14	41	37						1.03		6		se.				17	4	9		0.0	0.0
Broken Arrow	765	11	52	29.31	30.14		50.9		80	4	62	29	20	40	34						4.77		7	8,267	n.	42	se.	4	14	8	8	4.3	0.0	0.0
Muskogee	652	4					52.9		84	2	65	28	28	41	42						7.36		7		w.				14	9	7		0.0	0.0
Oklahoma City	1,214	10	47	28.84	30.15	+.07	51.3	+3.4	75	2	61	29	14	42	31	44	40	74			2.37	+0.1	7	7,733	s.	35	se.	4	18	10	2	3.1	0.0	0.0
Southern Slope.							**52.6**	**+1.7**												**65**	**1.04**	**−0.2**									**4.9**		
Abilene	1,738	10	52	28.29	30.12	+.05	55.1	+2.5	80	4	65	31	14	45	35	47	42	71			1.97	+0.7	8	6,387	se.	34	s.	4	9	10	11	5.4	T.	0.0
Amarillo	3,676	10	49	26.33	30.11	+.06	47.2	+3.4	77	2	59	17	13	35	40	39	34	68			1.39	+0.2	7	8,044	s.	44	sw.	4	18	7	5	3.5	0.1	0.0
Del Rio	944	64	71	29.08	30.08	+.03	61.3	+2.0	82	4	70	39	27	53	37						0.28	−0.9	5	6,161	se.	32	n.	13	5	8	17	7.1	0.0	0.0
Roswell	3,566	75	85	26.42	30.07	+.04	47.0	−1.1	78	10	60	17	14	34	44	38	28	56			0.53	−0.6	6	5,327	s.	35	w.	4	16	7	7	3.6	0.0	0.0
Southern Plateau.							**46.1**	**−2.9**												**58**	**0.71**	**+0.1**									**2.4**		
El Paso	3,762	110	133	26.22	30.02	+.02	50.1	−0.8	77	8	62	27	13	38	34	40	30	53			0.29	−0.3	5	7,955	e.	43	e.	15	19	6	5	2.8	T.	0.0
Santa Fe	7,013	38	53	23.24	30.08	+.05	35.8	−2.4	60	9	46	14	13	26	31	29	24	69			1.13	+0.4	8	4,386	se.	33	w.	4	17	3	10	4.3	8.8	0.4
Flagstaff	6,908	10	59	23.32	30.01	−.01	33.0	−1.6	59	18	45	−1	4	21	40	26		67			2.31		7	6,023	w.	36	sw.	3	19	6	5		21.6	10.0
Phoenix	1,108	11	81	28.82	30.00	+.02	55.0	−3.7	80	19	71	32	5	39	40	43	32	51			1.04	+0.1	3	3,461	e.	24	e.	15	25	3	2	1.4	0.0	0.0
Yuma	141	9	54	29.86	30.02	+.04	58.3	−4.1	80	19	73	34	4	44	37	47	38	53			0.66	+0.3	2	2,988	n.	21	n.	21	26	4	0	0.9	0.0	0.0
Independence	3,957	9	41	26.02	30.11	+.06	44.6	−4.6	69	15	58	19	30	32	35	35	27	58			0.44	+0.2	1	4,535	nw.	28	se.	9	19	7	4	2.8	0.0	0.0
Middle Plateau.							**36.4**	**−3.3**												**64**	**1.10**	**+0.2**									**4.2**		
Reno	4,532	74	81	25.54	30.17	+.06	36.8	−4.2	62	17	50	8	30	24	39	30	23	65			0.97	−0.1	7	3,099	w.	32	w.	7	17	6	7	3.5	8.5	3.8
Tonopah	6,090	12	20	24.09	30.11		36.4		56	18	45	13	3	28	24	30	20	53			0.41	−0.5	3	5,871	w.	37	se.	9	15	12	3	3.5	1.0	0.5
Winnemucca	4,344	18	56	25.70	30.20	+.06	33.6	−3.9	62	17	48	6	30	19	44	27	21	68			0.52	−0.2	6	4,281	ne.	27	sw.	17	13	8	9	4.7	2.6	T.
Modena	5,479	10	43	24.64	30.09	+.01	34.2	−4.8	62	18	47	12	4	22	42	27	20	62			1.00	+0.4	5	5,763	w.	38	s.	9	15	10	5	3.6	9.5	4.8
Salt Lake City	4,360	163	203	25.69	30.13	+.01	38.0	−3.1	56	9	45	25	14	31	21	33	29	71			3.33	+1.9	10	3,665	se.	39	s.	9	13	3	14	5.5	18.2	6.5
Grand Junction	4,602	60	68	25.42	30.05	−.03	39.4	−0.5	62	3	51	20	14	28	31	32	26	63			0.38	−0.2	5	3,565	se.	35	s.	3	13	10	7	4.5	T.	0.0
Northern Plateau.							**35.7**	**−3.2**												**76**	**0.62**	**−0.8**									**6.9**		
Baker	3,471	48	53	26.56	30.23	+.07	33.4	−1.5	55	17	43	12	30	24	26	30	23	72			0.52	−0.7	5	4,118	se.	25	nw.	2	12	4	14	5.6	T.	0.0
Boise	2,739	78	86	27.30	30.22	+.05	37.0	−2.6	58	7	47	17	30	27	25	33	27	67			0.52	−0.3	4	2,750	se.	21	se.	12	14	8	8	4.5	T.	0.0
Lewiston	757	40	48	29.42	30.25	+.13	38.4	−2.5	61	17	46	23	3	31	28						0.97	−0.4	6	1,643	e.	25	w.	17	3	3	24	8.5	0.7	T.
Pocatello	4,477	60	68	25.55	30.19	+.05	34.0	−2.3	52	16	43	15	22	25	33	29	25	74			0.49	−0.1	6	4,262	se.	40	sw.	18	11	4	15	5.9	1.3	0.0
Spokane	1,929	101	110	28.14	30.25	+.15	34.4	−4.1	52	9	40	24	22	29	20	32	30	83			0.30	−2.0	2	2,927	n.	36	sw.	17	2	7	21	8.2	T.	T.
Walla Walla	991	57	65	29.15	30.25	+.12	36.9	−6.0	59	17	41	26	3	33	22	35	33	84			0.95	−1.2	9	2,175	s.	30	w.	17	4	2	24	8.6	0.2	0.0
North Pacific Coast Region.							**44.7**	**−1.1**												**84**	**2.63**	**−4.2**									**6.9**		
North Head	211	11	56	29.89	30.12	+.07	47.8	+0.1	59	23	52	36	30	44	15	44	40	79			3.54	−2.8	15	8,481	e.	62	s.	15	14	9	7	4.5	0.0	0.0
Port Angeles	29	8	53	30.11	30.14		41.7		56	6	48	30	29	36	20						1.56	−2.9	11	3,822	s.	38	sw.	17	4	3	23	8.1	0.0	0.0
Seattle	125	215	250	30.04	30.17	+.13	43.6	−0.9	57	26	49	31	30	38	20	41	38	82			1.45	−4.4	9	4,468	se.	42	s.	17	5	9	16	6.9	0.0	0.0
Tacoma	213	113	120	29.94	30.17	+.13	41.9	−2.2	56	26	48	28	30	36	23						1.48	−7.0	10	2,789	sw.	30	w.	17	3	6	21	7.8	0.0	0.0
Tatoosh Island	86	9	57	30.02	30.11	+.14	47.0	+1.1	53	4	50	40	29	44	11	44	43	88			4.85	−7.2	16	13,124	e.	68	s.	15	3	6	21	7.9	0.0	0.0
Yakima	1,071	5					36.7		58	16	44	20	3	30	31						0.11		5		nw								T.	0.0
Medford	1,425	4																																
Portland, Oreg	153	68	106	30.00	30.17	+.07	43.6	−3.2	56	7	49	28	27	38	22	41	37	80			2.94	−3.5	14	4,179	se.	25	e.	6	8	7	15	6.3	T.	T.
Roseburg	510	9	57	29.60	30.16	+.04	44.3	−1.6	59	17	50	30	14	38	25	42	41	89			2.59	−1.8	14	1,417	ne.	15	w.	17	2	15	13	6.7	0.0	0.0
Middle Pacific Coast Region.							**50.7**	**−3.0**												**76**	**3.28**	**+0.2**									**3.6**		
Eureka	62	73	89	30.07	30.14	+.03	48.2	−2.8	61	6	54	34	3	42	20	46	44	86			3.32	−2.4	12	3,117	se.	30	n.	27	12	7	11	5.2	0.0	0.0
Point Reyes	490	7	18	29.53	30.05		52.2	−0.8	71	26	57	42	29	48	20						3.40		4	13,280	nw.	72	nw.	28	15	8	7	3.8	0.0	0.0
Red Bluff	332	50	56	29.74	30.11	.00	49.4	−4.4	70	24	60	30	30	38	37	44	39	70			3.54	+0.4	4	3,850	nw.	30	n.	29	23	3	4	2.2	0.0	0.0
Sacramento	69	106	117	30.03	30.10	+.01	49.8	−3.8	63	24	58	36	22	41	25	46	41	73			3.03	+0.9	5	3,989	se.	26	s.	8	15	9	6	3.6	0.0	0.0
San Francisco	155	208	243	29.92	30.09	.00	54.3	−2.0	65	24	60	43	29	48	17	49	45	75			3.77	+1.3	4	4,730	nw.	30	w	1	18	5	7	3.4	0.0	0.0
San Jose	141	12	110	29.95	30.10		50.5	−3.9	68	25	62	30	29	39	33						2.72	+0.8	5	3,871	s.	27	se.	7	16	9	5	3.6	0.0	0.0
South Pacific Coast Region.							**55.9**	**−2.0**												**64**	**2.03**	**+0.8**									**2.9**		
Fresno	327	89	98	29.75	30.12	+.06	51.0	−3.6	67	6	61	34	3	42	31	46	41	72			0.62	−0.4	5	3,292	nw.	29	sw.	9	17	3	10	4.2	0.0	0.0
Los Angeles	338	159	191	29.69	30.06	+.04	59.8	−1.1	82	26	69	43	30	51	23	49	38	53			1.44	0.0	5	4,150	ne.	26	sw.	9	22	3	5	2.2	0.0	0.0
San Diego	87	62	70	29.94	30.04	+.02	58.0	−1.7	79	26	67	45	18	49	30	50	43	64			0.75	−0.1	4	3,932	nw.	28	s.	9	21	7	2	2.3	0.0	0.0
San Luis Obispo	201	32	40	29.86	30.08	+.02	54.8	−1.5	82	26	67	32	3	42	43	46	40	67			5.30	+3.6	5	2,932	n.	17	se.	8	20	5	5	2.9	0.0	0.0
West Indies.																																		
San Juan, P. R	82	9	54																															
Panama Canal.																																		
Balboa Heights	118	7	97																															
Colon	25	5	71																															
Alaska.																																		
Juneau	80	11	54	29.68	29.77		38.2		52	7	43	21	17	34	20	36	34	87			11.43		25	6,046	se.	38	se.	20	3	3	24	8.5	8.9	T.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, November, 1922.*

Stations.	Altitude above mean sea level, Jan. 1, 1919.	Pressure.			Temperature of the air.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max.+ mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*In.*	*In.*	*In.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*In.*	*In.*	*In.*
St. Johns, N. F.	125												
Sydney, C. B. I.	48	29.72	29.77	−.18	35.3	−1.8	39.9	30.7	50	23	6.34	−0.90	12.0
Halifax, N. S.	88	29.74	29.85	−.16	35.4	−1.9	41.3	29.4	52	22	1.94	−3.72	3.4
Yarmouth, N. S.	65	29.81	29.88	−.14	37.4	−2.5	42.7	32.0	51	24	1.42	−3.14	2.8
Charlottetown, P. E. I.	38	29.77	29.81	−.15	33.9	−1.6	38.3	29.6	49	21	1.29	−2.68	0.3
Chatham, N. B.	28	29.79	29.82	−.15	29.6	−1.4	36.9	22.4	49	6	1.73	−2.02	7.8
Father Point, Que.	20	29.90	29.92	−.04	27.5	−1.4	33.2	21.9	44	12	1.72	−1.39	12.4
Quebec, Que.	296	29.63	29.97	−.05	31.5	+2.5	36.9	26.1	48	14	1.83	−1.93	9.9
Montreal, Que.	187	29.75	29.96	−.07	35.7	+3.9	41.0	30.4	54	17	1.74	−2.00	1.9
Stonecliffe, Ont.	489												
Ottawa, Ont.	236	29.73	30.00	−.02	35.7	+4.0	42.1	29.3	60	18	1.44	−1.10	2.8
Kingston, Ont.	285	29.70	30.02	−.02	39.4	+4.4	45.7	33.2	57	17	0.82	−2.42	0.8
Toronto, Ont.	379	29.62	30.04	.00	40.7	+5.1	46.6	34.8	61	21	1.48	−1.66	5.3
Cochrane, Ont.	930												
White River, Ont.	1,244	28.62	29.97	−.01	27.0	+6.5	34.7	19.2	53	−8	1.72	−0.13	3.8
Port Stanley, Ont.	592	29.43	30.09	+.04	41.7	+4.9	48.8	34.7	66	20	2.06	−1.31	12.4
Southampton, Ont.	656	29.29			39.9	+4.9	45.8	34.0	66	22	2.37	−1.33	7.0
Parry Sound, Ont.	688	29.28	29.98	−.03	36.0	+3.9	42.7	29.3	57	14	3.25	−1.12	12.2
Port Arthur, Ont.	644	29.30	30.03	+.04	33.5	+9.5	38.5	28.5	51	11	1.93	+0.60	4.5
Winnipeg, Man.	760												
Minnedosa, Man.	1,690	28.18	30.05	+.01	27.9	+10.6	34.8	21.1	50	−3	2.79	+1.79	19.3
Le Pas, Man.	860												
Qu'Appelle, Sask.	2,115	27.74	30.05	+.05	27.1	+8.3	34.4	19.9	50	−14	2.10	+1.21	21.0
Medicine Hat, Alb.	2,144												
Moose Jaw, Sask.	1,759												
Swift Current, Sask.	2,392	27.46	30.16	+.14	29.2	+6.0	39.1	19.4	59	−4	0.44	−0.25	4.4
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Edmonton, Alb.	2,150												
Prince Albert, Sask.	1,450	28.49	30.11	+.08	27.5	+12.1	35.3	19.8	49	−2	0.06	−0.77	0.5
Battleford, Sask.	1,592	28.29	30.08	+.06	28.6	+12.3	38.9	18.4	55	0	T.	−0.58	T.
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.87	30.13	+.14	44.1	+0.9	48.5	39.7	56	36	1.91	−5.06	0.0
Barkerville, B. C.	4,180												
Triangle Island, B. C.	680												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151												

SEISMOLOGICAL REPORTS FOR NOVEMBER, 1922.

W. J. HUMPHREYS, Professor in Charge.

TABLE 1.—*Noninstrumental earthquake reports. November, 1922.*

[Weather Bureau, Washington, January 3, 1923.]

Day.	Approximate time, Greenwich civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
1922.	*H. m.*		° ′	° ′			*Sec.*			
Nov. 4	3 18	Eureka	40 48	124 10	2	1	1	None	Felt by several	L. B. Cooper.
7	15 00	do	40 48	124 10	2	1	1	do	do	J. M. Jones.
28	3 00	Whittier	34 00	118 00						Press report.
		ILLINOIS.								
27	3 30?	Cairo	37 00	89 10	2			None	Felt by several	W. E. Barron.
	3 30	Clinton	40 10	89 00	2	2	Few.	do	Felt by one	Mrs. A. H. Montgomery
		Eldorado	37 50	88 30	8(?)	2	5	Loud	Felt by many	C. T. Wilson.
		McLeansboro	38 07	88 33	4	1	10	Rumbling	do	J. C. Carver.
		White Hall	39 25	90 30	Faint.	1	(?)	None	Felt by several	G. R. Adams.
		INDIANA.								
27	3 30	Mount Vernon	37 56	87 54		1	60		Felt by many	G. B. Green.
	? ?	Bedford	38 55	86 30	2	2	120, 60	Rumbling	Felt by several	E. W. Moore.
		KENTUCKY.								
27	3 30	Bardwell	36 52	89 01					Barely noticeable	G. Jayner.
		Blandville	37 00	89 00	2	1		Rattling	Slight	E. W. Horr.
	3 28	Hickman	36 34	89 12	2	1		None	Felt by several	D. J. Oliver.
	3 30	Hopkinsville	36 50	87 30		1	Short.		do	W. E. Graves.
	3 32	Marion	37 20	88 00		1	75		do	B. C. Paris.
	3 30	Paducah	37 10	88 40	4	1	5ca.		Felt by many	J. T. Ross.
		Wycliffe	37 00	89 05	2	2	4	None	Felt by several	M. R. Jones.
		TENNESSEE.								
27	3 30	Clarksville	36 30	87 25	4?	1		Moaning	Felt by many	B. L. Miller.
	3 25	Dickson	36 10	87 30				None	Felt by one	J. M. Freeman.
	3 30 ca	Nashville	36 10	86 45	2	2	15-20	Rattling	do	Mrs. E. E. French.
		WYOMING.								
Oct. 25	2 30	Buffalo	44 20	106 40	4	1	60	Faint	Felt by two	A. Bulow.
Nov. 10	16 45	Yellowstone Park	45 00	110 40	2	1	2-3	None	Felt by several	E. Bowman.

TABLE 2.—*Instrumental seismological reports, November, 1922.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols and description of stations, see REVIEW for January, 1922.]

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
COLORADO. *Regis College, Denver.*								
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 11	.....	P.....	5 44 ..	.....	.....	.....	.....	Waves broken and very irregular; sinusoidal; very large period.
		S.....	5 53?..	.....	.....	.....	.....	
		L.....	6 03?..	30–40	*3,000	*3,000	.....	
		M_N.....	6 16?..	30–40	.....	.....	.....	
		M_E.....	6 19?..	30–40	.....	.....	.....	
		C_N.....	6 30 ..	.....	.....	.....	.....	
		C_E.....	6 33 ..	.....	.....	.....	.....	
		F.....	7	.....	.....	.....	.....	
DISTRICT OF COLUMBIA. *U. S. Weather Bureau, Washington.*								
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 4	.....	L.....	3 39 30	.....	.....	.....	.....	
		L.....	3 42 ..	12	.....	.....	.....	
		F.....	3 52 *ca.*	.....	.....	.....	.....	
7	.....	P.....	23 11 02	.....	.....	.....	7,400	
		S.....	23 19 53	.....	.....	.....	.....	
		L.....	23 34 12	.....	.....	.....	.....	
		L.....	23 40 ..	18	.....	.....	.....	
8	.....	F.....	9 10 ..	.....	.....	.....	.....	
11	.....	iP.....	4 43 32	.....	.....	.....	7,600	Chile.
		S.....	4 52 30	.....	.....	.....	.....	
		L.....	5 06 17	30	.....	.....	.....	
		L.....	5 15 ..	20	.....	.....	.....	
		L.....	5 40 ..	16	.....	.....	.....	
		L.....	7 12 ..	20	.....	.....	.....	
		F.....			.....	.....	.....	Lost in succeeding quake.
11	.....	P.....	7 37 45	.....	.....	.....	.....	
		S.....	7 47 37	.....	.....	.....	.....	
		L.....	8	.....	.....	.....	.....	
		F.....	8 40 *ca.*	.....	.....	.....	.....	
11	.....	P.....	18 20 20	.....	.....	.....	7,400	
		S.....	18 29 11	.....	.....	.....	.....	
		eL.....	18 47 ..	20	.....	.....	.....	
		F.....	19 10 *ca.*	.....	.....	.....	.....	
17	.....	P.....	11 13 54	.....	.....	.....	8,800	
		S.....	11 23 54	.....	.....	.....	.....	
		L.....	11 40 30	20	.....	.....	.....	
		F.....	12 20 *ca.*	.....	.....	.....	.....	
26	.....	P?.....	13 41 00	.....	.....	.....	.....	
		S.....	13 50 20	.....	.....	.....	.....	
		F.....	14 05 *ca.*	.....	.....	.....	.....	
ILLINOIS. *U. S. Weather Bureau, Chicago.*								
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 2	.....	e.....	4 26 22	.....	.....	.....	.....	
		F.....	4 50 *ca.*	.....	.....	.....	.....	
4	.....	S?.....	3 30 00	.....	.....	.....	.....	
		L.....	3 33 50	18	.....	.....	.....	
		F.....	4 *ca.*	.....	.....	.....	.....	
4	.....	e.....	5 *ca.*	.....	.....	.....	.....	
		L.....	5 06 *ca.*	16	.....	.....	.....	
		F.....	5 25 *ca.*	.....	.....	.....	.....	
4	.....	S?.....	5 45 08	.....	.....	.....	.....	
		L.....	5 49 45	.....	.....	.....	.....	
		F.....	6 10 *ca.*	.....	.....	.....	.....	
7	.....	P.....	23 11 28	.....	.....	.....	7,800	
		S.....	23 20 35	.....	.....	.....	.....	
		L?.....	23 34 15	.....	.....	.....	.....	
		L.....	23 39 40	20	.....	.....	.....	
		L.....	23 49 ..	16	.....	.....	.....	
8	.....	F.....	2 *ca.*	.....	.....	.....	.....	
11	.....	iP.....	4 44 00	.....	.....	.....	7,700	Chile.
		S.....	4 53 07	.....	.....	.....	.....	
		M.....	5 07 ..	.....	.....	.....	.....	L indeterminate.
		F.....	11 *ca.*	.....	.....	.....	.....	
11	.....	P.....	18 20 45	.....	.....	.....	7,700	
		S.....	18 29 50	.....	.....	.....	.....	
		L.....	18 43 35	24	.....	.....	.....	
		L.....	18 58 ..	15	.....	.....	.....	
		F.....	20 30 *ca.*	.....	.....	.....	.....	
17	.....	P.....	11 14 30	.....	.....	.....	7,600	
		S.....	11 23 30	.....	.....	.....	.....	
		L.....	11 37 10	20	.....	.....	.....	
		F.....	15 10 *ca.*	.....	.....	.....	.....	
26	.....	P.....	13 41 16	.....	.....	.....	8,000	
		S.....	13 50 37	.....	.....	.....	.....	
		L.....	13 14 03	20	.....	.....	.....	
		F.....	14 30 *ca.*	.....	.....	.....	.....	

* Trace amplitude.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
NEW YORK. *Cornell University, Ithaca.*								
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 7	.....	e.....	23 12 ..	.....	.....	.....	.....	Uncertain because of poor soot, and local disturbances.
		S?.....	23 20 42	.....	.....	.....	.....	
		L.....	23 35 ..	23	.....	.....	.....	
		L.....	23 39 ..	18	.....	.....	.....	
		L.....	23 42 ..	20	.....	.....	.....	
		F.....	24 16 ..	.....	.....	.....	.....	
11	.....	P.....	4 43 52	.....	.....	.....	.....	
		S.....	4 53 07	.....	.....	.....	.....	
		SR1...	4 58 42	.....	.....	.....	.....	
		L.....	5 04 30	40	.....	.....	.....	
		L.....	5 14 ..	22	.....	.....	.....	
		L.....	5 20 ..	19	.....	.....	.....	
		L.....	7 03 ..	32	.....	.....	.....	
		L.....	7 11 ..	24	.....	.....	.....	
		F.....	8 33 ..	.....	.....	.....	.....	
11	.....	L.....	18 48 ..	18	.....	.....	.....	
		L.....	18 51 ..	24	.....	.....	.....	
		L.....	18 54 ..	18	.....	.....	.....	
		F.....	19 08 ..	.....	.....	.....	.....	
17	.....	eP_N...	11 14 17	.....	.....	.....	.....	
		PR1..	11 17 28	.....	.....	.....	.....	
		S.....	11 23 23	.....	.....	.....	.....	
		L.....	11 36 ..	20	.....	.....	.....	
		L.....	11 44 ..	20	.....	.....	.....	
		L.....	11 55 ..	18	.....	.....	.....	
		F.....	12 12 ..	.....	.....	.....	.....	
CANAL ZONE. *Panama Canal, Balboa Heights.*								
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 7	.....	.....	.....	.....	.....	.....	.....	Slight tremors from distant disturbance, direction unknown, 22:03 to 22:45.
10	.....	P_E.....	14 39 22	.....	.....	.....	320 *ca.*	Probably SW.
		P_N.....	14 39 20	.....	.....	.....	.....	
		S_E.....	14 39 56	.....	.....	.....	.....	
		S_N.....	14 39 54	.....	.....	.....	.....	
		M_E.....	14 40 24	.....	*5,000	.....	.....	
		M_N.....	14 40 00	.....	.....	*4,000	.....	
		F_E.....	14 46 00	.....	.....	.....	.....	
		F_N.....	14 47 00	.....	.....	.....	.....	
11	.....	P_E.....	4 40 26	.....	.....	.....	4,300*ca.*	Direction SE.
		P_N.....	4 40 00	.....	.....	.....	.....	
		S_E.....	4 46 14	.....	.....	.....	.....	
		S_N.....	4 46 08	.....	.....	.....	.....	
		L_E.....	4 49 46	.....	.....	.....	.....	
		L_N.....	4 49 28	.....	.....	.....	.....	
		M_E.....	4 49 46	.....	*14,000	.....	.....	
		M_N.....	4 53 38	.....	.....	*16,000	.....	
		F_E.....	6 44 00	.....	.....	.....	.....	
		F_N.....	6 46 00	.....	.....	.....	.....	
17	.....	P_N.....	11 10 20	.....	.....	.....	4,000*ca.*	Direction southerly; E too small to compute.
		S_N.....	11 16 05	.....	.....	.....	.....	
		M_N.....	11 24 00	.....	.....	*500	.....	
		F_N.....	12 30 00	.....	.....	.....	.....	
VERMONT. *U. S. Weather Bureau, Northfield.*								
1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 7	.....	P.....	23 11 40	.....	.....	.....	8,000	
		S.....	23 21 01	.....	.....	.....	.....	
		eL.....	23 45 ..	.....	.....	.....	.....	
		L.....	23 49 ..	18	.....	.....	.....	
8	.....	F.....	0 05 *ca.*	.....	.....	.....	.....	
11	.....	P.....	4 44 06	.....	.....	.....	8,100	
		S.....	4 53 33	.....	.....	.....	.....	
		L?.....	4 09 ..	24	.....	.....	.....	
		L.....	4 20 ..	16	.....	.....	.....	
		F.....	8 05 ..	.....	.....	.....	.....	
17	.....	S?.....	11 23 52	.....	.....	.....	.....	
		L.....	11 46 ..	20	.....	.....	.....	
		F.....	12 *ca.*	.....	.....	.....	.....	
26	.....	e.....	13 50 38	.....	.....	.....	.....	
		F.....	13 56 ..	.....	.....	.....	.....	

* Trace amplitude.

Reports for November, 1922, have not been received from the following stations:

ALABAMA.—*Spring Hill College*, Mobile.

ALASKA.—*U. S. C. & G. S. Magnetic Observatory*, Sitka.

ARIZONA.—*U. S. C. & G. S. Magnetic Observatory*, Tucson.
CALIFORNIA.—*Theosophical University*, Point Loma.
DISTRICT OF COLUMBIA.—*Georgetown University*, Washington.
HAWAII.—*U. S. C. & G. S. Magnetic Observatory*, Honolulu.
MARYLAND.—*U. S. C. & G. S. Magnetic Observatory*, Cheltenham.
MASSACHUSETTS.—*Harvard University*, Cambridge.
MISSOURI.—*St. Louis University*, St. Louis.
NEW YORK.—*Fordham University*, New York.
PORTO RICO.—*U. S. C. & G. S. Magnetic University*, Vieques.
CANADA.—*Dominion Observatory*, Ottawa; *Dominion Meteorological Service*, Toronto and Victoria.

TABLE 3.—*Late reports (instrumental).*

NEW YORK. *Cornell University, Ithaca.*

1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 4	.....	L.....	9 58 ..	20	.....	.....	.....	
		F.....	10 18 ..	.....	.....	.....	.....	
11	.....	eP_N...	6 52 24	.....	.....	.....	.....	
		eS_N...	6 58 06	.....	.....	.....	.....	
		eL.....	7 03 35	25	.....	.....	.....	
		F.....	7 26 ..	.....	.....	.....	.....	
12	.....	L.....	19 42 ..	20	.....	.....	.....	
		F.....	20 14 ..	.....	.....	.....	.....	
June 12	.....	eP.....	4 54 04	4	.....	.....	.....	
		S.....	4 59 26	8	.....	.....	.....	
		L.....	5 02 18	44	.....	.....	.....	
		F.....	6 15 ..	.....	.....	.....	.....	
12	.....	e.....	10 50 ..	4	.....	.....	.....	
		e.....	10 55 ..	6	.....	.....	.....	
		e_N.....	10 57 30	9	.....	.....	.....	
		L.....	*11 01 40	15	.....	.....	.....	
		F.....	11 35 ..	.....	.....	.....	.....	
16	.....	e_N.....	21 13 ..	6	.....	.....	.....	
		eL.....	21 16 ..	13	.....	.....	.....	
		F.....	21 46 ..	.....	.....	.....	.....	
July 2	.....	eP.....	13 45 24	5	.....	.....	.....	
		ePRL.	13 47 30	4	.....	.....	.....	
		S.....	13 52 41	6	.....	.....	.....	
		e_N.....	13 56 30	24	.....	.....	.....	
		eL.....	14 04 ..	27	.....	.....	.....	
		F.....	15 29 ..	.....	.....	.....	.....	
2	.....	P.....	21 27 10	.....	.....	.....	.....	Periods chiefly 1 and 2 sec.; waves of 6 sec. overrun by 1 and 2 sec. waves.
		e.....	21 27 40	6	.....	.....	.....	
		F.....	21 34 ..	.....	.....	.....	.....	
10	.....	e.....	9 47 34	5	.....	.....	.....	L faint.
		e.....	9 50 01	6	.....	.....	.....	
		S.....	9 55 14	7	.....	.....	.....	
Aug. 11	.....	i.....	8 41 11	6	.....	.....	.....	Clock error uncertain.
		eL.....	8 58 ..	24	.....	.....	.....	
		F.....	9 09 ..	.....	.....	.....	.....	
11	.....	$P?_E$...	13 57 37	5	.....	.....	.....	
		e_N.....	13 59 05	5	.....	.....	.....	
		$S?_N$...	14 06 25	6	.....	.....	.....	
		L.....	14 14 ..	22	.....	.....	.....	
		F.....	14 43 ..	.....	.....	.....	.....	
13	.....	e.....	0 31 23	6	.....	.....	.....	e may be artificial disturbance; P lost in changing sheets.
		eS?....	0 32 24	6	.....	.....	.....	
		eL.....	0 46 ..	30	.....	.....	.....	
		F.....	1 17 ..	.....	.....	.....	.....	

TABLE 3.—*Late reports (instrumental)*—Continued.

NEW YORK. *Cornel University, Ithaca*—Continued.

1922.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Aug. 16	.....	L.....	16 33 ..	28	.....	.....	.....	
		L.....	16 49 ..	20	.....	.....	.....	
		F.....	16 58 ..	.....	.....	.....	.....	
18	.....	L.....	5 30 ..	20	.....	.....	.....	
		F.....	5 37 ..	.....	.....	.....	.....	
29	.....	L.....	18 07 ..	24	.....	.....	.....	
		F.....	18 27 ..	.....	.....	.....	.....	
30	.....	e.....	22 48 30	5	.....	.....	.....	
		e.....	22 51 ..	.....	.....	.....	.....	
		e.....	22 54 36	.....	.....	.....	.....	
		e.....	22 57 18	.....	.....	.....	.....	
		L.....	23 00 18	18	.....	.....	.....	
		F.....	23 14 ..	.....	.....	.....	.....	
Sept. 1	.....	eP.....	19 35 19	7	.....	.....	.....	
		S.....	19 44 56	10	.....	.....	.....	
		e.....	19 51 18	40	.....	.....	.....	
		L.....	20 06 ..	25	.....	.....	.....	
		L.....	20 14 ..	30	.....	.....	.....	
		L.....	20 19 ..	26	.....	.....	.....	
		F.....	21 11 ..	.....	.....	.....	.....	
4	.....	e.....	17 14 28	4	.....	.....	.....	
		i.....	17 19 13	5	.....	.....	.....	
		i.....	17 21 10	4	.....	.....	.....	
		e.....	17 22 18	6	.....	.....	.....	
		F.....	17 30 ..	.....	.....	.....	.....	
14	.....	L.....	20 26 ..	25	.....	.....	.....	
		L.....	20 29 ..	30	.....	.....	.....	
		F.....	21 15 ..	.....	.....	.....	.....	
16	.....	L.....	23 45 ..	26	.....	.....	.....	
17	.....	F.....	0 13 ..	.....	.....	.....	.....	
17	.....	L.....	11 04 ..	20	.....	.....	.....	
		L.....	11 12 ..	18	.....	.....	.....	
		F.....	11 18 ..	.....	.....	.....	.....	
29	.....	e.....	21 43 ..	6	.....	.....	.....	
		e.....	21 49 ..	8	.....	.....	.....	
		F.....	22 13 ..	.....	.....	.....	.....	
30	.....	e.....	23 46 30	3	.....	.....	.....	
		F.....	23 53 ..	.....	.....	.....	.....	
Oct. 6	.....	e.....	5 44 12	4	.....	.....	.....	
		eL.....	5 52 ..	5	.....	.....	.....	
		L.....	5 53 12	4	.....	.....	.....	
		F.....	6 10 ..	.....	.....	.....	.....	
11	.....	iP_N...	14 59 44	4	.....	.....	.....	
		PRI..	15 02 18	5	.....	.....	.....	
		S.....	15 07 48	6	.....	.....	.....	
		ee.....	15 14 26	28	.....	.....	.....	
		L.....	15 19 ..	37	.....	.....	.....	
		F.....	15 56 ..	.....	.....	.....	.....	
15	.....	e.....	0 34 ..	.....	.....	.....	.....	
		L.....	0 40 30	28	.....	.....	.....	
		L.....	0 44 ..	22	.....	.....	.....	
		L.....	0 49 ..	24	.....	.....	.....	
		L.....	0 57 ..	20	.....	.....	.....	
		F.....	1 15 ..	.....	.....	.....	.....	
24	.....	eP.....	21 33 30	6	.....	.....	.....	Beginning uncertain because of micros.
		PRI..	21 36 43	7	.....	.....	.....	
		S.....	21 43 10	7	.....	.....	.....	
		L.....	21 56 ..	20	.....	.....	.....	
		L.....	22 07 ..	20	.....	.....	.....	
		L.....	22 14 ..	17	.....	.....	.....	
		F.....	22 48 ..	.....	.....	.....	.....	
27	.....	L.....	15 31 ..	22	.....	.....	.....	
		F.....	15 43 ..	.....	.....	.....	.....	
30	.....	e.....	2 09 ..	6	.....	.....	.....	
		F.....	2 18 ..	.....	.....	.....	.....	

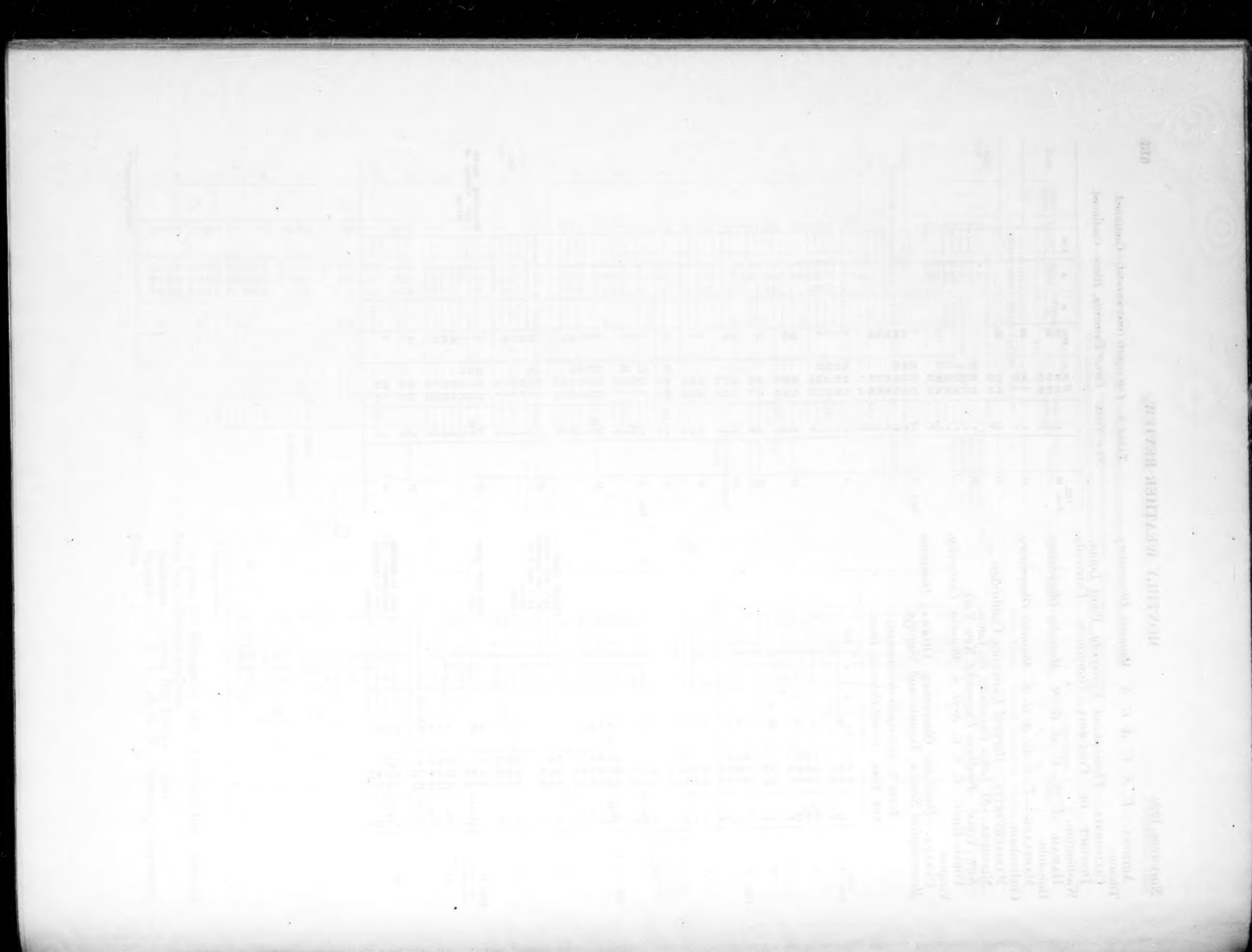


Chart I. Tracks of Centers of Anticyclones, November, 1922. (Inset) Departure of Monthly Mean Pressure from Normal.
(Plotted by Wilfred P. Day.)

Chart I. Tracks of Centers of Anticyclones, November, 1922. (Inset) Departure of Monthly Mean Pressure from Normal.

(Plotted by Wilfred P. Day.)

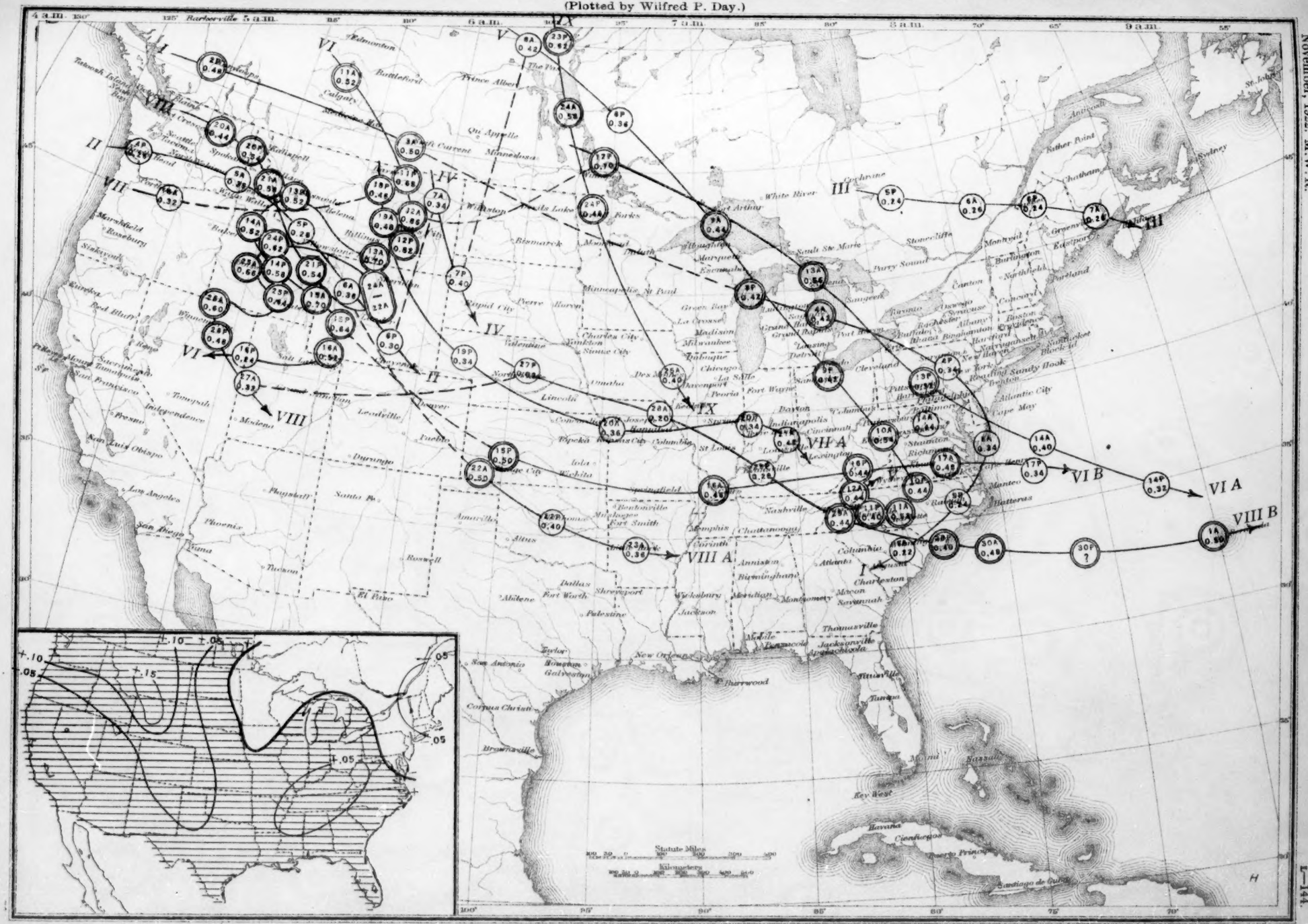


Chart II. Tracks of Centers of Cyclones, November, 1922. (Inset) **Change in Mean Pressure from Preceding Month.**

(Plotted by Wilfred P. Day.)

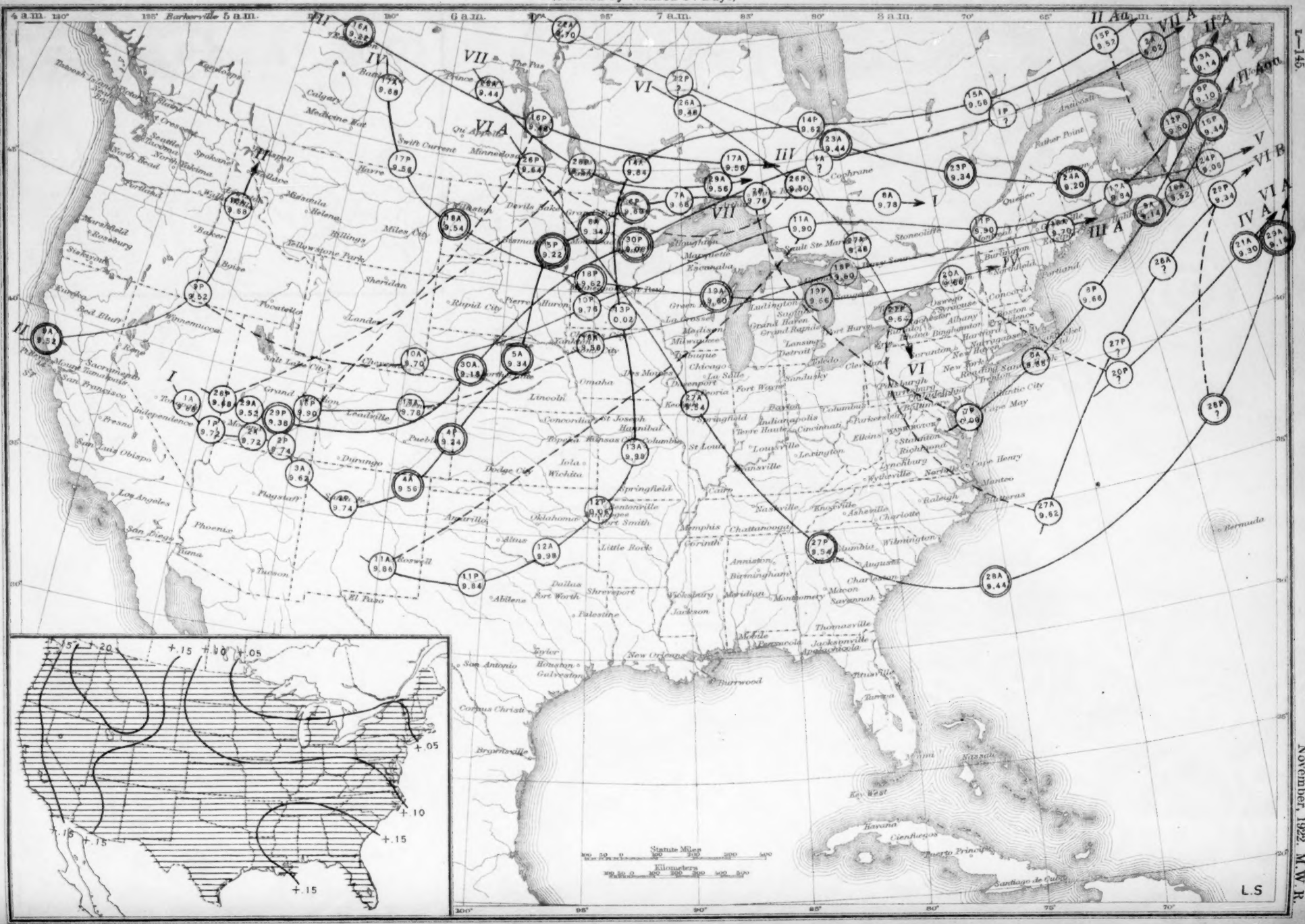


Chart III. Departure (°F.) of the Mean Temperature from the Normal, November, 1922.

Chart IV. Total Precipitation, Inches, November, 1922. (Inset) Departure of Precipitation from Normal.

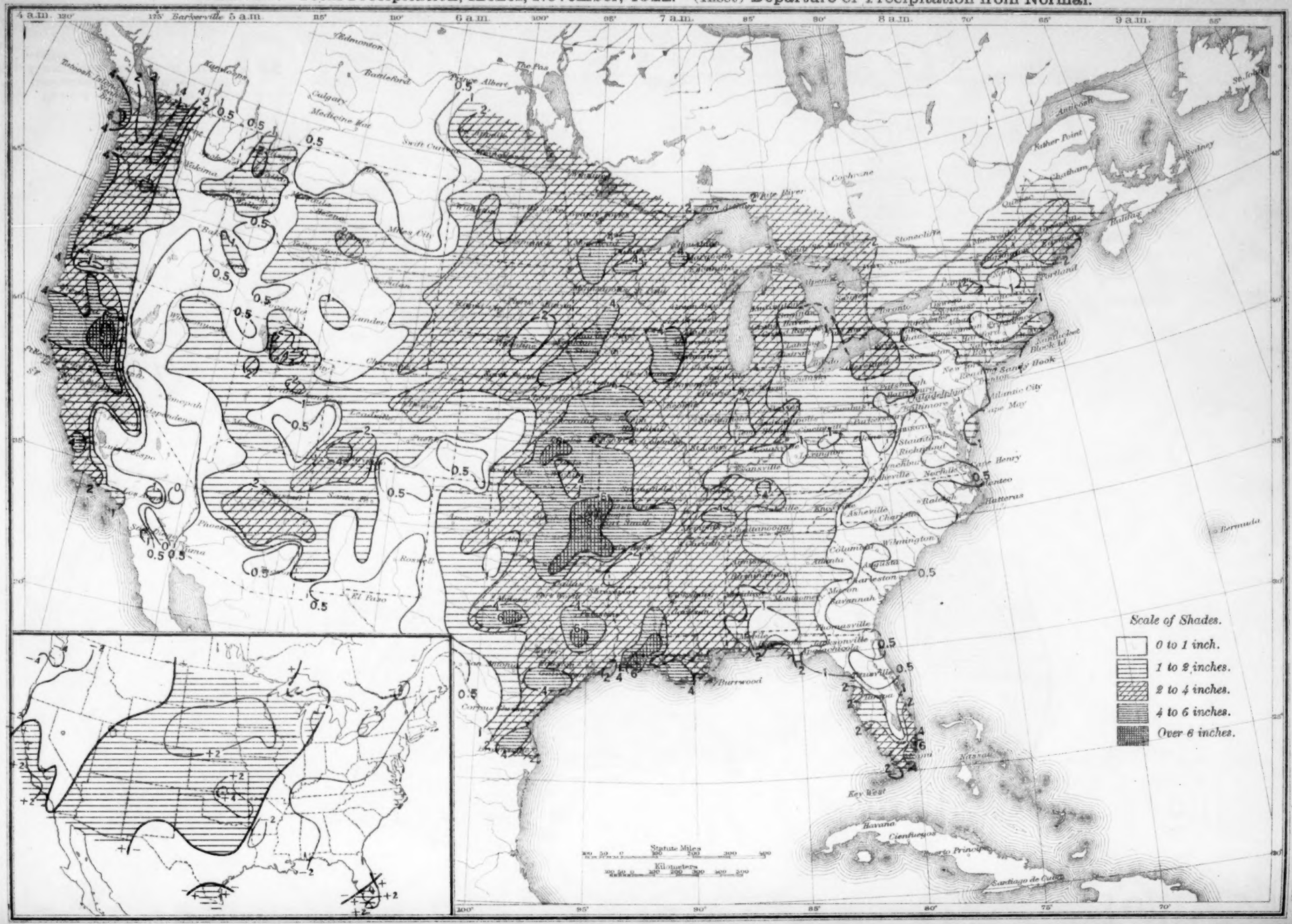


Chart V. Percentage of Clear Sky between Sunrise and Sunset, November, 1922.

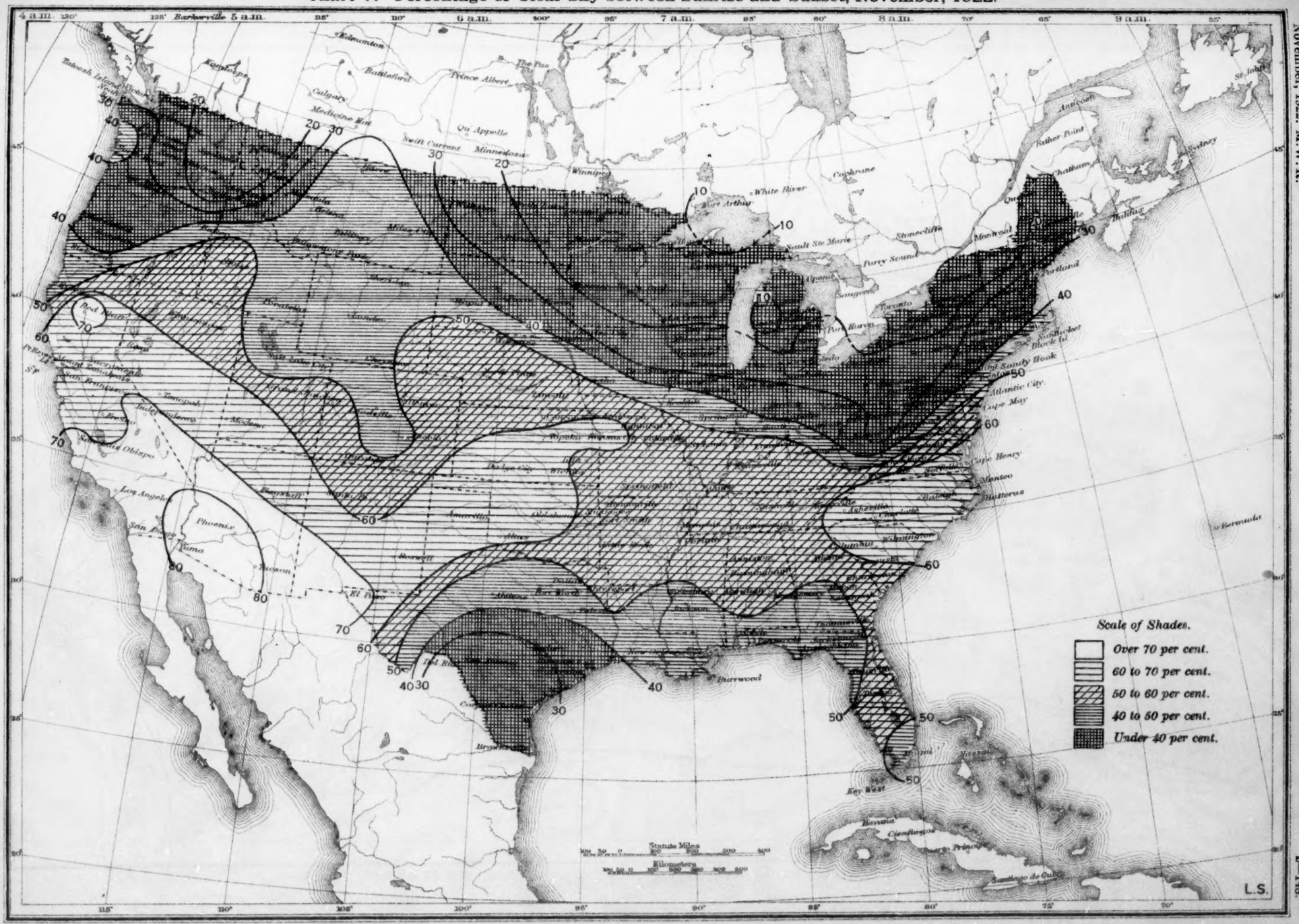


Chart VI. Isobars at Sea-level and Isotherms at Surface; Prevailing Winds, November, 1922.

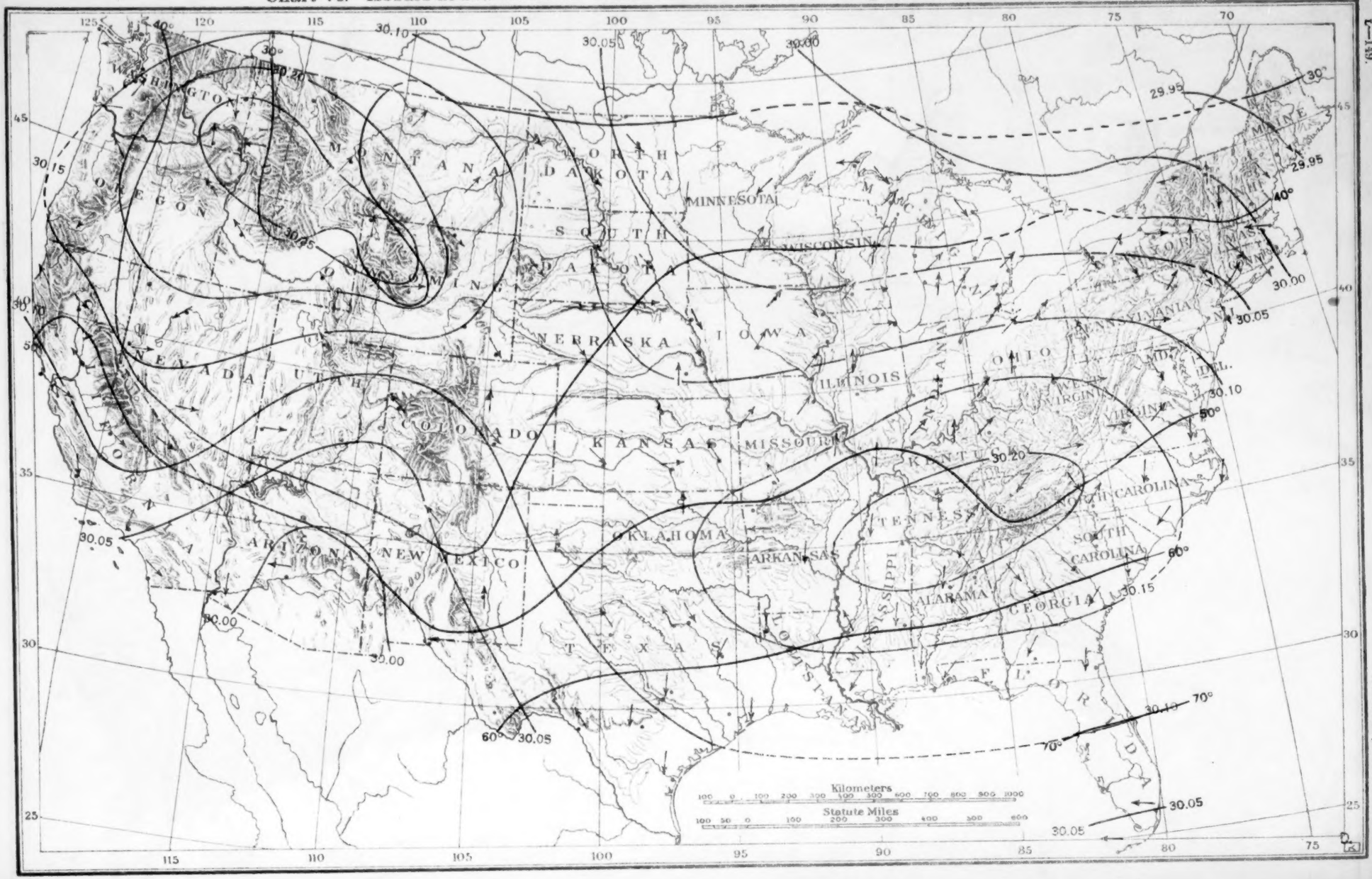


Chart VII. Total Snowfall, Inches, November, 1922. (Inset) Depth of Snow on Ground at end of Month.

Chart VIII. Weather Map of North Atlantic Ocean, November 22, 1922.

Chart VIII. Weather Map of North Atlantic Ocean, November 22, 1922.
(Plotted by F. A. Young.)

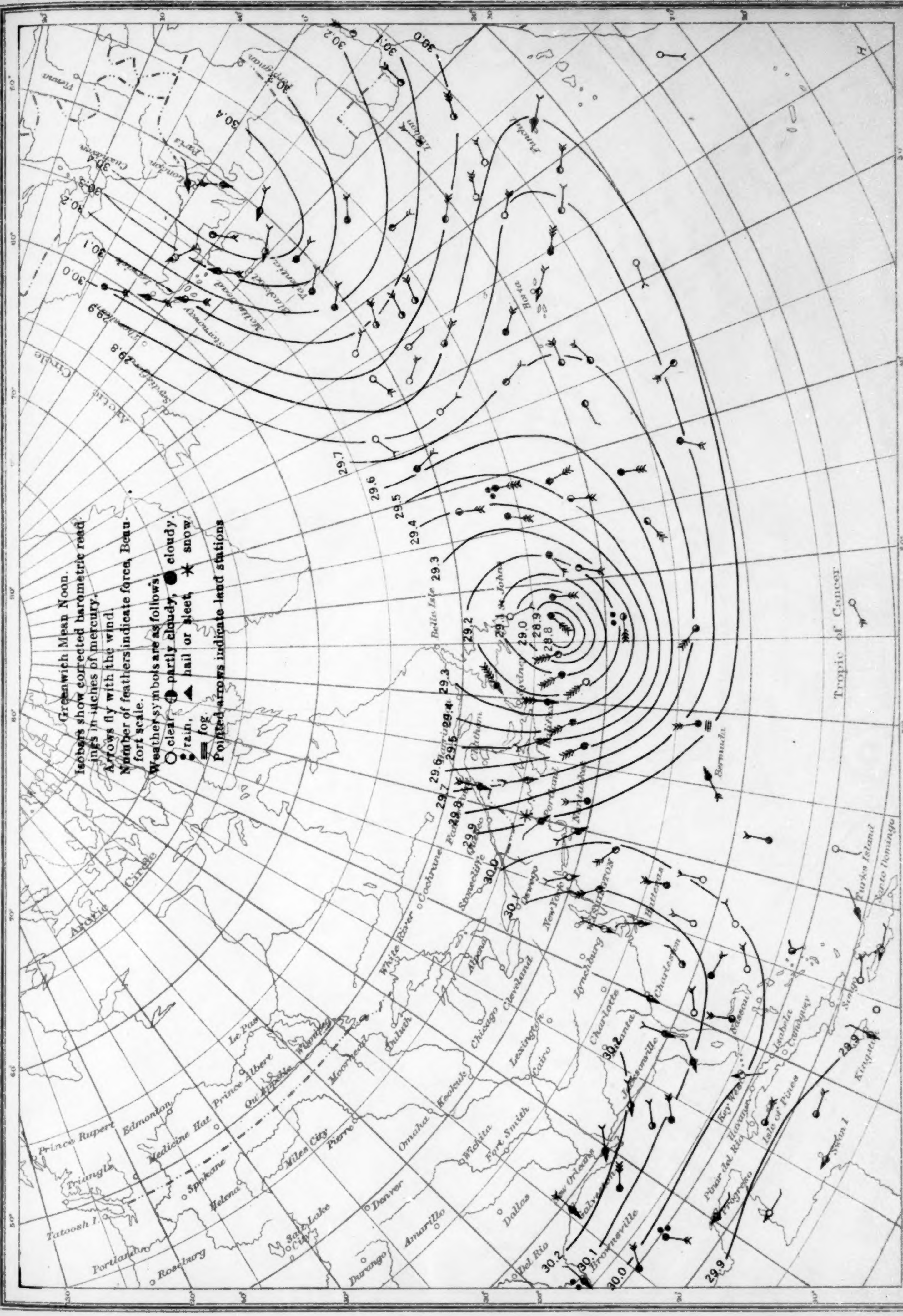


Chart IX. Weather Map of North Atlantic Ocean, November 23, 1922.

(Plotted by F. A. Young.)

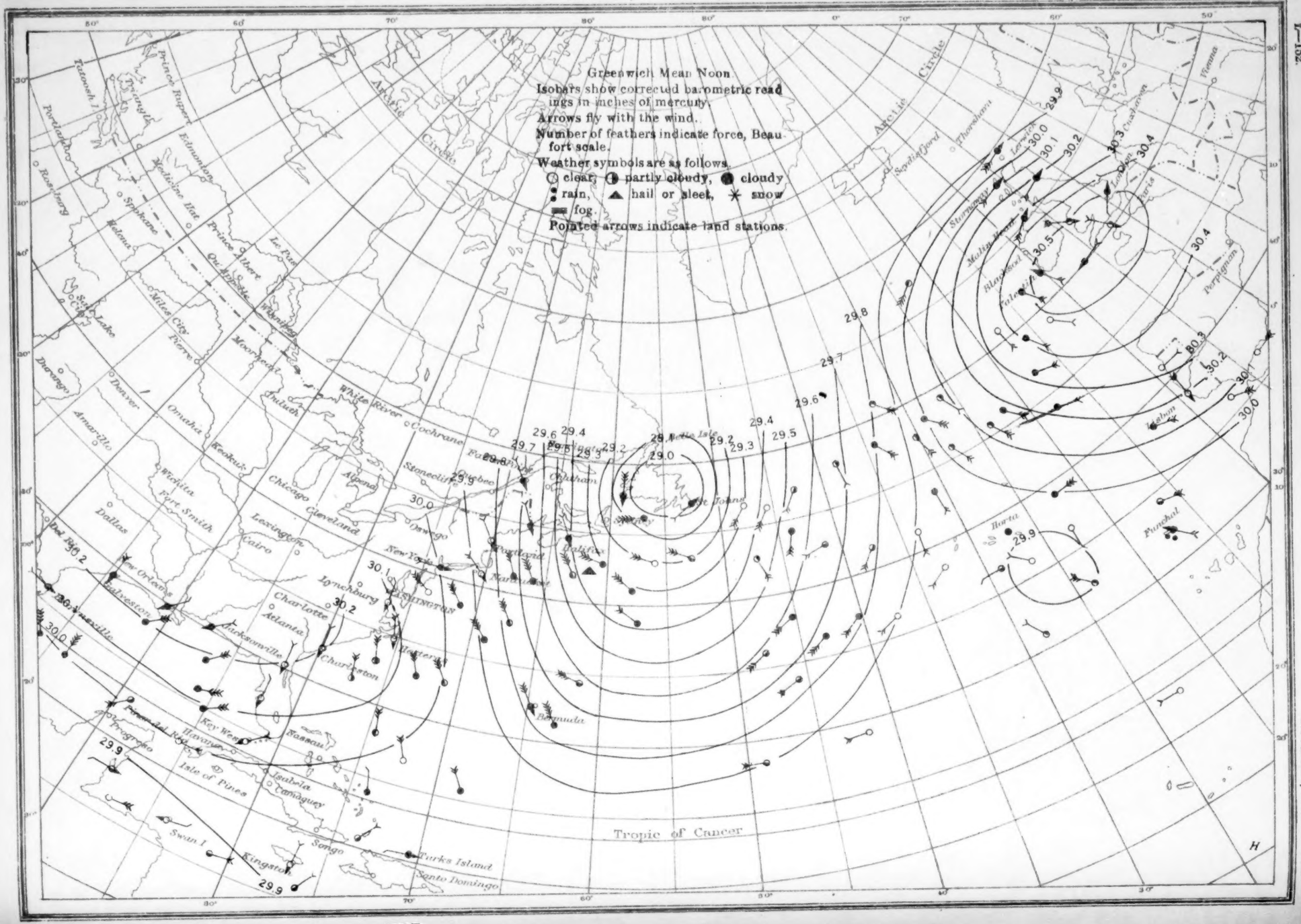

Greenwich Mean Noon
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows.
clear, partly cloudy, cloudy
rain, hail or sleet, snow
fog.
Pointed arrows indicate land stations.
Tropic of Cancer

Chart X. Weather Map of North Atlantic Ocean, November 24, 1922.

(Plotted by F. A. Young.)

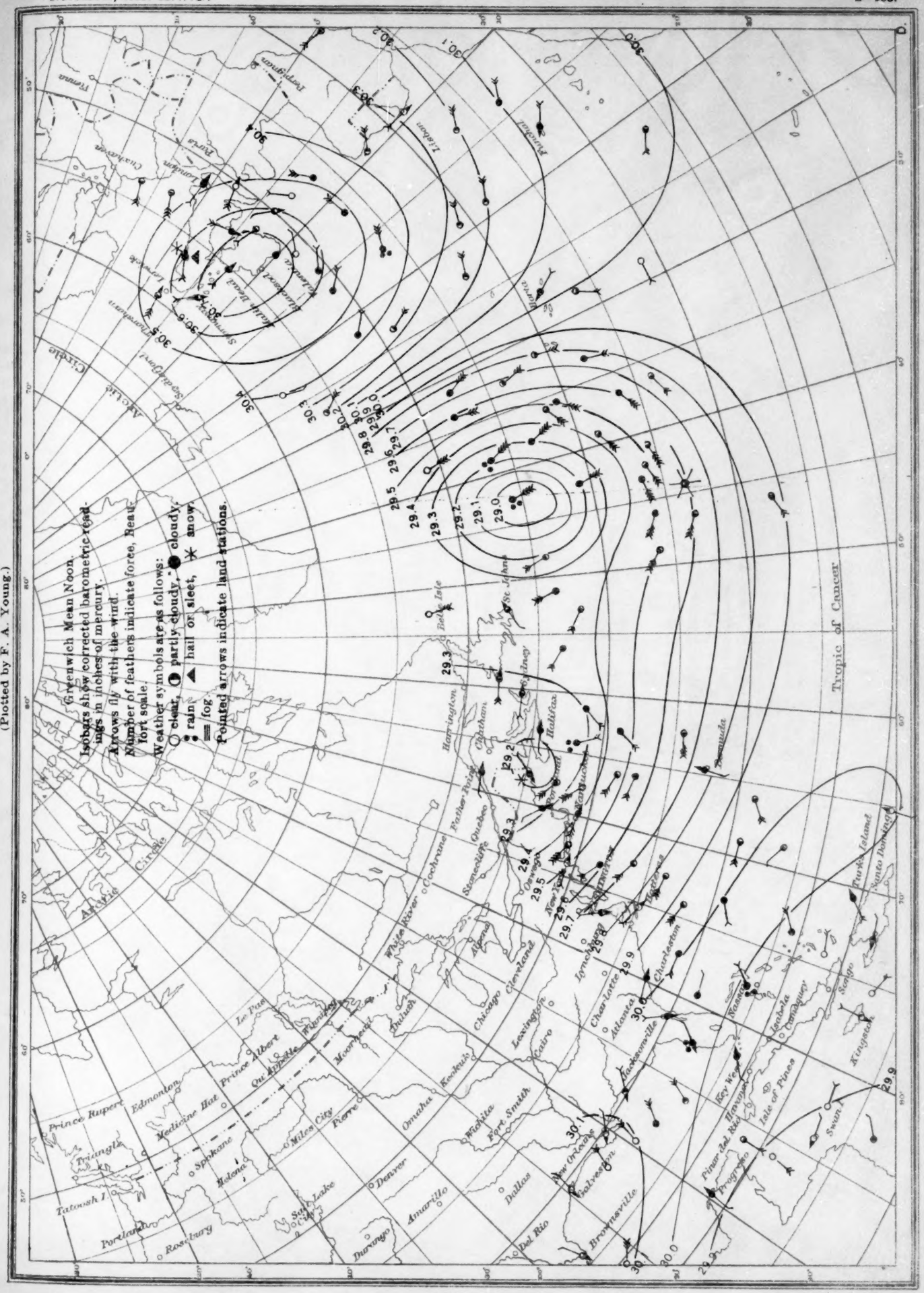
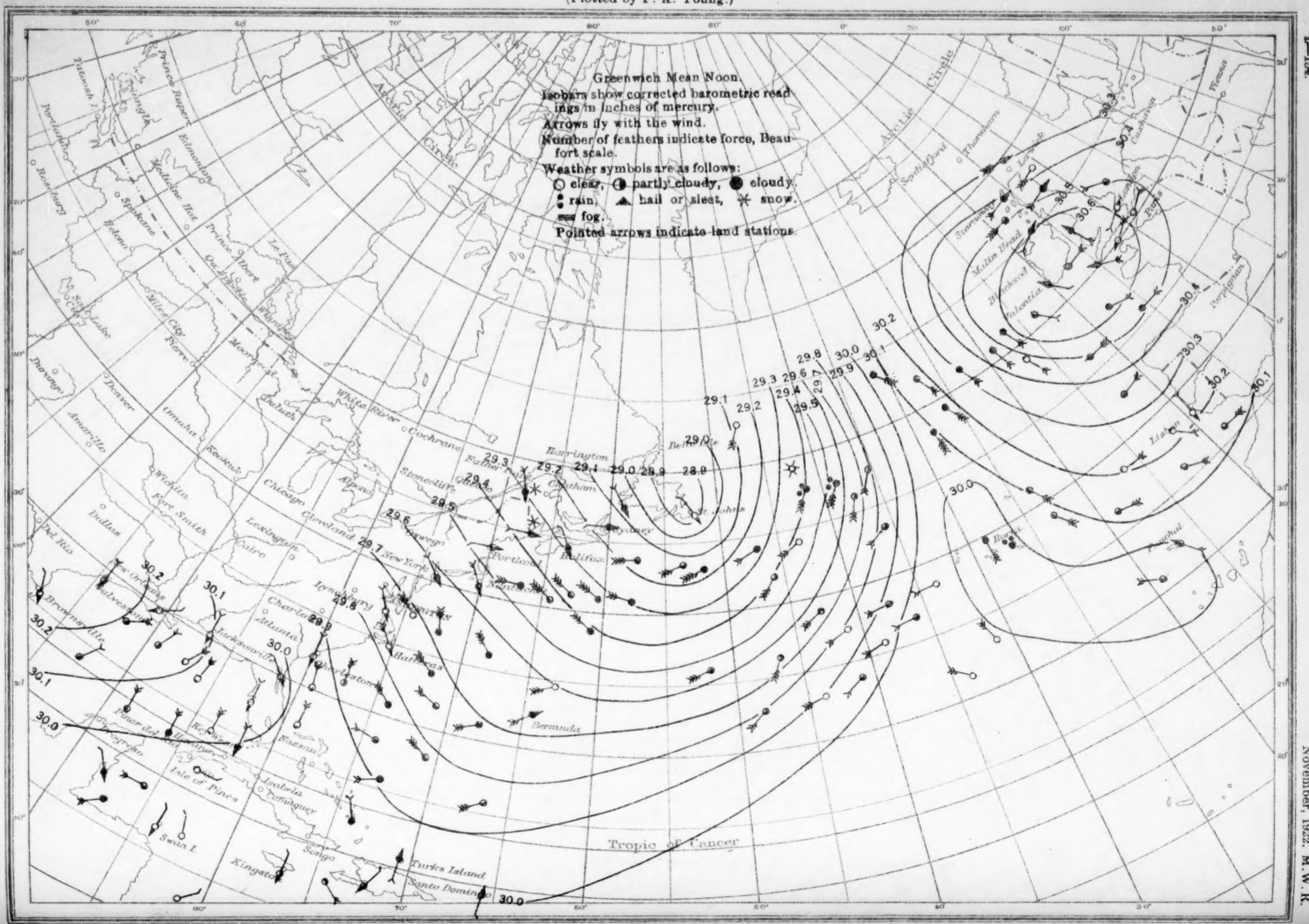


Chart X. Weather Map of North Atlantic Ocean, November 24, 1922.

(Plotted by F. A. Young.)

Chart XI. Weather Map of North Atlantic Ocean, November 25, 1922.

(Plotted by F. A. Young.)



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NOVEMBER, 1922.

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CORRIGENDA.

REVIEW, July, 1922:

Page 369, second column, 8th line, "8.02" inches *should read* "2.98" inches.

REVIEW, September, 1922:

Page 477, the title of the article *should read:* "The climatograph: A new form of chart for climatic phenomena."

† In marine separate.